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```
%preparing workspace
clear
close all
clc

%defining constants
hbar=1.0546e-34;
m0=9.1e-31;
e=1.6e-19;
k=1.38e-23;

%forming a task
L=1e-8;
a=L/2;
Np=1000;
dx=L/Np;
X=linspace(-L/2,L/2, Np);
koef=-hbar^2/(2*m0*12*(dx^2));

%defining potential feild
U=abs(X/(L/2)*e/2);

%numerical solution
E=eye(Np)*(-30);
for i=1:Np-1
    E(i,i+1)=E(i,i+1)+16;
    E(i+1,i)=E(i+1,i)+16;
end
for i=1:Np-2
    E(i,i+2)=E(i,i+2)-1;
    E(i+2,i)=E(i+2,i)-1;
end

%Hamiltonian
H=E*koef+diag(U);

%finding eigenvalues and eigenvectors
[P,Eii]=eig(H);
Ei=diag(Eii);

%normalization edigvectors
P=P*sqrt(1/dx);

%plotting main and two petrubated states
F=figure('Units', 'normalized', 'OuterPosition', [1 0 1 1]);
subplot(2,2,1)
plot(X*1e9, U/e, '--k', 'LineWidth', 1)
hold on;
for i=1:3
    plot(X*1e9, Ei(i)/e+0.02*P(:,i)/P(islocalmax(P(:,i)),1));
    plot(X*1e9, Ei(i)*ones(1,Np)/e, '--r');
end
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xlabel('$x, nm$', 'Interpreter', 'latex');
ylabel('$E, eV$', 'Interpreter', 'latex');
title('$\Psi, E$', 'Interpreter', 'latex');
text(0,0.3,sprintf('$E_0 = %2.2g eV$', Ei(1)/e), 'Interpreter', 'latex')
E1=Ei(1)/e;
grid on;
clear dx E Ei Eii H i koef P U

lmbd=2*L;
%sg=L/10;
mu=0;

%initializing WF
syms A sg real positive
syms E x real
w(x)=1/sqrt(sqrt(pi)*sg)*exp(-(x-mu).^2/(2*sg^2)+1i*2*pi*(x-mu)/lmbd);

%defining Potential Feild
U=e*1e8*heaviside(-x+a)*heaviside(a+x)*(heaviside(x)*x-x*heaviside(-x));

%solving for E_med
dE=conj(w)*(-hbar^2/(2*m0)*diff(w,x,2)+U*w);
E=int(dE,-a,a);

SG=linspace(0.01*L,2*L,100);
Esg=(double(subs(E,sg,SG)));
tf=islocalmin(Esg);
sigma=SG(tf);
E=double(Esg(tf))/e;
if isempty(sigma)
    sigma=SG(length(SG));
    E=double(Esg(length(SG)))/e;
end
subplot(2,2,4)
plot(SG,Esg/e,sigma,E,'*');
text(sum(xlim)*0.7,sum(ylim)*0.3,...
    sprintf('$E_{min} = %2.2g eV$ \n $sg_{min} = %2.2g nm$',
    [E;sigma*1e9]), 'Interpreter', 'latex')
xlabel('$\sigma, nm$', 'Interpreter', 'latex');
ylabel('$E, eV$', 'Interpreter', 'latex');
title('$E=E(\sigma), E$', 'Interpreter', 'latex');
grid on;
E2=E;

Psi=abs(double(subs(w, {x, sg},{X,sigma})));
Psimax=Psi(islocalmax(Psi));
Psi=Psi/sqrt((X(2)-X(1))*sum(Psi.*conj(Psi)));
subplot(2,2,2)
plot(X*1e9,double(subs(U,x,X))/e,'--k')
hold on
plot(X*1e9,E+0.02*Psi/Psimax)
plot(X*1e9, E*ones(1,1000),'--r');
text(0,0.3,sprintf('$E_{var} = %2.2g eV$',E), 'Interpreter', 'latex')

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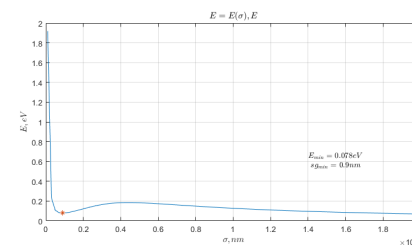
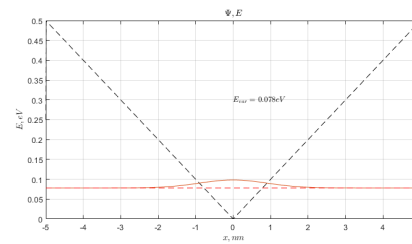
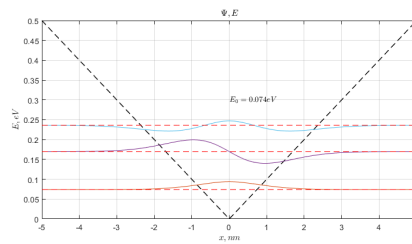
xlabel('$x,\text{nm}$', 'Interpreter', 'latex');
ylabel('$E,\text{eV}$', 'Interpreter', 'latex');
title('$\Psi,\text{eV}$', 'Interpreter', 'latex');
grid on;
clear A dE E Esg lmbd m0 mu Np Psi Psimax sg SG sigma tf U w x X

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E1/E2

ans =

0.9466



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