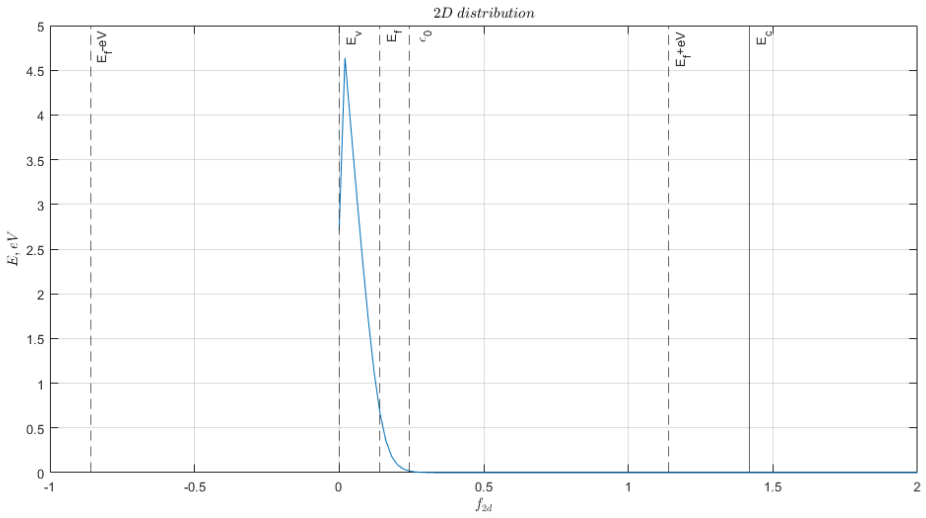
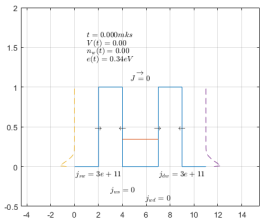
```
%preparing workspace
clc
clear
close all

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

%initial paramets
T=300;                  %room temperature, K
a=3e-9;                 %size of chanel, 3nm
b=2e-9;                 %size of barrier, 2nm
U0=1*e;                 %height of barrier, 1 eV
m=0.067*m0;             %eff. mass in GaAs, kg
mb=(0.067+0.083*0.5)*m0;%eff. mass in AlGaAs(0.5), kg
Ef=0.14*e;              %Fermi energy, eV (at T=300)(0,14)
Eg=1.42*e;              %gap energy, eV
v=1e6;                  %frequency, 1Mhz
Ez=0.1*e;               %connection energy
V=@(t)1*sin(2*pi*v*t);  %periodic voltage, V

eps0=0.244*e;
eps=@(nw,t)eps0-e*V(t)/2+Ez;%*nw;

Eks=@(nw,t)eps(nw,t);
Ekd=@(nw,t)eps(nw,t)+e*V(t);
Ekw=@(nw,t)eps0;

wsw=@(nw,t)sqrt(2*Eks(nw,t)/m)/b;
wdw=@(nw,t)sqrt(2*Ekd(nw,t)/m)/b;
wws=@(nw,t)sqrt(2*Ekw(nw,t)/m)/b;
wwd=@(nw,t)wws(nw,t);

f2d=@(EF,E,E0) log(1+exp(-(E-EF)/(k*T))).*heaviside(E-E0);

E=linspace(0,2)*e;
figure('Units','normalized','OuterPosition',[.2 .2 .6 .6])
plot(E/e,f2d(Ef,E,0))
xline(Eg/e,'-','E_c')
xline(Ef/e,'--','E_f')
xline(0/e,'--','E_v')
xline(Ef/e-1,'--','E_f-eV')
xline(Ef/e+1,'--','E_f+eV')
xline(eps0/e, '--','\epsilon_0')
grid on
ylabel('$E,eV$','Interpreter','latex')
xlabel('$f_{2d}$','Interpreter','latex')
title('$2D$ $distribution$','Interpreter','latex')
% close all
```

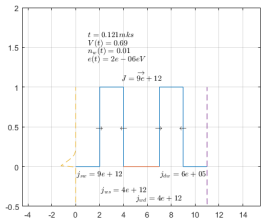
```
Efs=Ef;
Efd=@(t)Ef-e*(V(t));

ns=@(nw,t)f2d(Efs,eps(nw,t),0);       %
nd=@(nw,t)f2d(Efd(t),eps(nw,t),-e*(V(t)));    %


jsw=@(nw,t)wsw(nw,t).*ns(nw,t).*(1-nw);
jdw=@(nw,t)wdw(nw,t).*nd(nw,t).*(1-nw).*heaviside(eps(nw,t));
jws=@(nw,t)wws(nw,t).*nw.*heaviside(eps(nw,t)).*heaviside(eps(nw,t));
jwd=@(nw,t)wwd(nw,t).*nw.*heaviside(eps(nw,t));

eq = @(nw,t)jsw(nw,t)+jdw(nw,t)-jws(nw,t)-jwd(nw,t);
Nw0=0;
[t,Nw]=ode15s(@(t,nw)eq(nw,t),[0 2e-6],Nw0);

J=jsw(Nw,t)-jdw(Nw,t)-jws(Nw,t)+jwd(Nw,t);
V=V(t);

figure('Units','normalized','OuterPosition',[0 0 1 1])
x=[0,b,b,2*b,2*b,2*b+a,2*b+a,3*b+a,3*b+a,4*b+a]*1e9;
y=[0 0 1 1 0 0 1 1 0 0];
% index=[1 55 63 71 88 112];
index=round(linspace(1,length(t)/2.3,6));
for i=1:6
    subplot(2,3,i)
    plot(x,y)                                        %structure
    hold on
    grid on
    k=index(i);
    plot([2*b,2*b+a]*1e9,[1 1]*eps(Nw(k),t(k))/e)   %well energy value
    text(1,1.65, sprintf('$t=%2.3fmks
$',t(k)*1e6),'Interpreter','latex')
    text(1,1.55, sprintf('$V(t)=%2.2f$',V(k)),'Interpreter','latex')
    text(1,1.45, sprintf('$n_w(t)=%2.2f
$',Nw(k)),'Interpreter','latex')
    text(1,1.35, sprintf('$e(t)=%2.2geV$',eps(Nw(k),t(k))/
e),'Interpreter','latex')
        %source->well current
    text(b*1e9,0.5,'\rightarrow','HorizontalAlignment','center')
    text(b*1e9,-0.1,sprintf('$j_{sw}=%.1g
$',jsw(Nw(k),t(k))),'Interpreter','latex','HorizontalAlignment','center')
        %source<-well current
    text(2*b*1e9,0.5,'\leftarrow','HorizontalAlignment','center')
    text(2*b*1e9,-0.3,sprintf('$j_{ws}=%.1g
$',jws(Nw(k),t(k))),'Interpreter','latex','HorizontalAlignment','center')
        %drain<-well current
    text((2*b+a)*1e9,0.5,'\rightarrow','HorizontalAlignment','center')
    text((2*b+a)*1e9,-0.4,sprintf('$j_{wd}=%.1g
$',jwd(Nw(k),t(k))),'Interpreter','latex','HorizontalAlignment','center')
        %drain->well current
    text((3*b+a)*1e9,0.5,'\leftarrow','HorizontalAlignment','center')
```

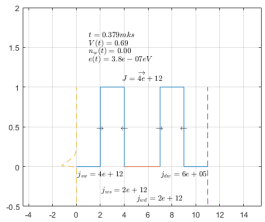
```
    text((3*b+a)*1e9,-0.1,sprintf('$j_{dw}=%.1g
$',jdw(Nw(k),t(k))),'Interpreter','latex','HorizontalAlignment','center')
        %sum current
    J_1=jsw(Nw(k),t(k))-jdw(Nw(k),t(k))-
jws(Nw(k),t(k))+jwd(Nw(k),t(k));
    if (J_1>=0)
        text((2*b
+a/2)*1e9,1.2,'\rightarrow','HorizontalAlignment','center')
        text((2*b+a/2)*1e9,1.1,sprintf('$J=%.1g
$',J_1),'Interpreter','latex','HorizontalAlignment','center')
    else
        text((2*b
+a/2)*1e9,1.2,'\leftarrow','HorizontalAlignment','center')
        text((2*b+a/2)*1e9,1.1,sprintf('$J=%.1g$',-
J_1),'Interpreter','latex','HorizontalAlignment','center')
    end
        %f2d f-s
    Uf=linspace(min(-e*(V(k)),0), e);
    plot(-f2d(Efs,Uf,0)/4,Uf/e,'--')
    plot((4*b+a)*1e9+f2d(Efd(t(k)),Uf,-e*(V(k)))/4,Uf/e,'--')

    ylim([-0.5, 2])
    xlim([-4.5, 15.5])
end

% close all
figure('Units','normalized','OuterPosition',[0 0 1 1])
subplot(2,2,1)
plot(t*1e6,Nw)
grid on
xlabel('$time,ms$','Interpreter','latex')
ylabel('$n_w$','Interpreter','latex')
title('$n_w=n_w(t)$','Interpreter','latex')
hold on


subplot(2,2,2)
plot(t*1e6,J*e)
grid on
xlabel('$time,ms$','Interpreter','latex')
ylabel('$J,{A \over m^2*s}$','Interpreter','latex')
title('$J=J(t)$','Interpreter','latex')

subplot(2,2,3)
plot(t*1e6,V)
grid on
xlabel('$time,ms$','Interpreter','latex')
ylabel('$Voltage,V$','Interpreter','latex')
title('$V=V(t)$','Interpreter','latex')

subplot(2,2,4)
plot(V,J*e,'-')
grid on
ylabel('$J,{A \over m^2*s}$','Interpreter','latex')
```

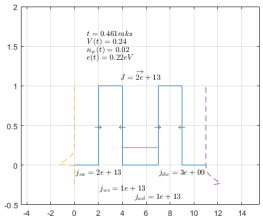
```
xlabel('$Voltage,V$','Interpreter','latex')
title('$VCC$','Interpreter','latex')
% xlim([0 inf])
% ylim([0 inf])
```

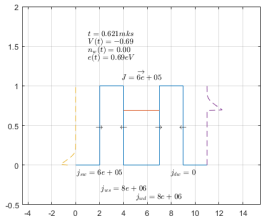


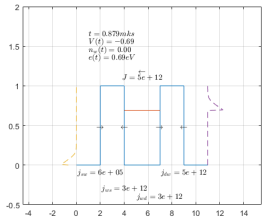


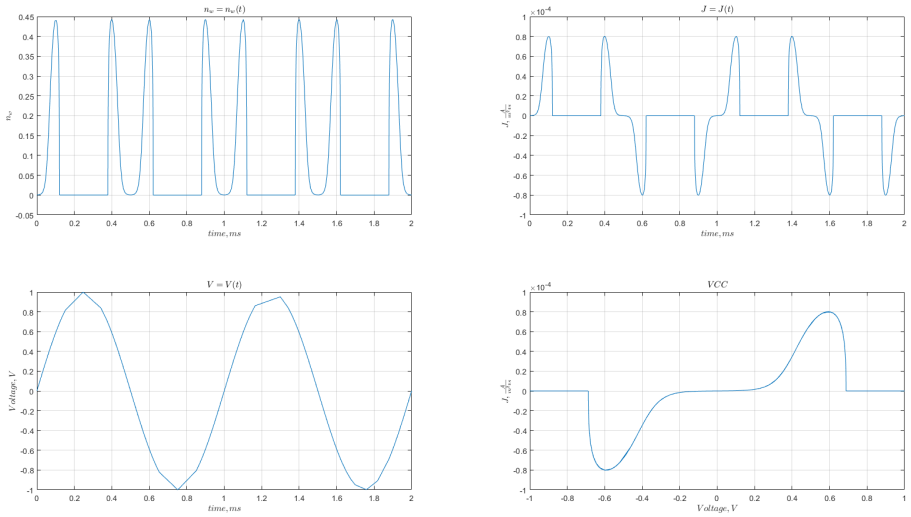












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