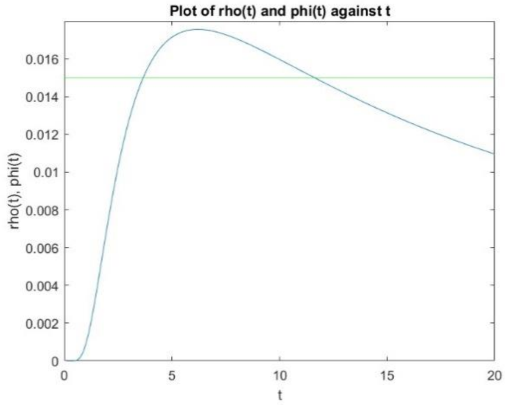
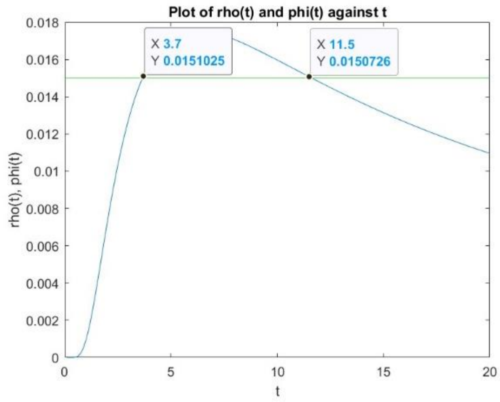
Assignment 2 Question 2

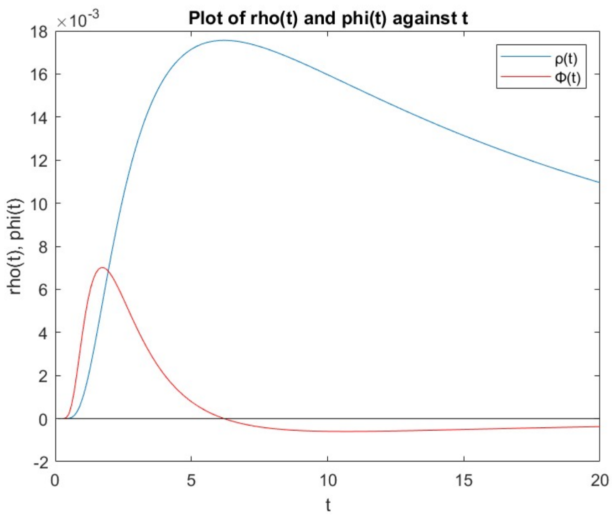
Question 2a





The graph for question 2a can be seen above. The smoke detector in the living room will be activated as the value of p is larger than 0.015 (represented by a horizontal green line in the two figure above) which is any time period between t = 3.7 and t = 11.5.

Question 2b



Based on the visual observation of the graph, we can see that the total flux of smoke particles into the living room is positive for the first segment of the graph. It increases to a maximum point and then decreases back towards the t-axis. The total mass of the smoke will keep on increasing after the flux of the smoke particles decreases. However, we can observe that once the total mass of the smoke reaches a maximum point, the total flux of smoke into the room will intersect with the t-axis. Once the intersection has occurred, the total mass of smoke particle in the living room will start to decrease. Since the total flux of smoke is an indication of the rate of smoke moving into the room through the 4 walls, the visual observation can be said to be an expected observation.

We can also be more analytical about the shown graph above. When the total flux is increasing, the total mass of smoke will also be increasing. Once the total flux reaches its maximum point, the gradient of the total mass of smoke graph will be at its maximum, causing a rapid increase in the total mass of the smoke. When the flux is decreasing, the total mass of smoke will still increase but at a slower rate (can be seen with a decreasing gradient of the graph). Once the flux hits the t-axis (reaches zero), there will not be a net flow of smoke. At this point, the total mass of smoke will start to decrease as it can be seen in the graph once there is a negative flux of smoke.

Written Code

```
% Written by Tan Jin Chun (32194471)
% Last Modified: 23/4/2022
% Assignment 2 Question 2

clc;clear;close all

% Given variables and equations
D = 3;
alpha = 1;
u = @(x,y,z,t,D,alpha) 1/(4*pi*D*t) * exp(-(x^2+y^2)/(4*D*t) - alpha*z/D);

% Modified Section
% You will need a function which returns the grad of u -- it is a vector.
gradu = @(x,y,z,t,D,alpha) [(-x/(2*D*t))*u(x,y,z,t,D,alpha); ...
(-y/(2*D*t))*u(x,y,z,t,D,alpha); ...
 (-alpha/D)*u(x,y,z,t,D,alpha)];
% ----------------------------------------------------------------------

% My ID is 32194471
% 50 intervals in each dimension of the room to discretise the room
N = 50;

% The boundary conditions for x, y and z
xmin = 1; %last number in ID
xmax = xmin+2;
x = linspace(xmin,xmax,N+1);
hx = x(2)-x(1);
ymin = 7; %second last number in ID
ymax = ymin+3;
y = linspace(ymin,ymax,N+1);
hy = y(2)-y(1);
zmin = 0;
zmax = 3;
z = linspace(zmin,zmax,N+1);
hz = z(2)-z(1);

x = x(1:end-1)+hx/2;
y = y(1:end-1)+hy/2;
z = z(1:end-1)+hz/2;

tmin = 0;
tmax = 20;
Nt = 200;
t = linspace(tmin,tmax,Nt+1); t = t(2:end);

%% ----- Volume Integral (Part a) -----------------------------------------
rho = zeros(Nt,1);

for n = 1:Nt

    %Calculate the volume integral at time t(n) and enter it as the value
    %rho(n)

% Modified Section -----------------------------------------------------
    % First, we would need to initialise the value of total mass of smoke
    tot_mass_smoke = 0;
```

```
    % We will be using three for loops here to approximate the total mass
    % of smoke at any moment of time (basically using the summation formula
    % shown in the assignment 2 notes)
    for i = x
        for j = y
            for k = z
                tot_mass_smoke = tot_mass_smoke + (u(i,j,k,t(n),D,alpha) * hx * hy
* hz);
            end
        end
    end

    % Assigning the value to rho before zeroing it to update the value
    rho(n) = tot_mass_smoke;

end

%-------------------------------------------------------------------------

% Plotting the figure
figure(1)
cla
plot(t,rho)
hold on

% % Plotting the line where the smoke detection in the living room activates
% % if the total smoke mass in the living room, p is larger than 0.015
% yline(0.015,'g');

% Labelling the figure
xlabel("t");
ylabel("rho(t), phi(t)");
title("Plot of rho(t) and phi(t) against t");


%% ---- Flux (Part b)------------------------------------------------------
% Initialising the value of phi
phi = zeros(Nt,1);


for n = 1:Nt

    %Calculate the flux integral at time t(n) and enter it as the value
    %phi(n)

% Modified Section-------------------------------------------------------

    % We can calculate the flux for each separate wall with the formula
    % given in the assignent sheet

    % Initialising the variables for the flux of the wall
    flux_wall_1 = 0;
    flux_wall_2 = 0;
    flux_wall_3 = 0;
    flux_wall_4 = 0;

    % Initialising the variable for the normal
    normal_1 = [-1,0,0];
    normal_2 = [0,-1,0];
```

```
    normal_3 = [1,0,0];
    normal_4 = [0,1,0];

    % The first wall
    for j = y
        for k = z
            flux_wall_1 = flux_wall_1 + (D *
dot(gradu(xmin,j,k,t(n),D,alpha),normal_1) * hy * hz );
        end
    end

    % The second wall
    for i = x
        for k = z
            flux_wall_2 = flux_wall_2 + (D *
dot(gradu(i,ymin,k,t(n),D,alpha),normal_2) * hx * hz );
        end
    end

    % The third wall
    for j = y
        for k = z
            flux_wall_3 = flux_wall_3 + (D *
dot(gradu(xmax,j,k,t(n),D,alpha),normal_3) * hy * hz );
        end
    end

    % The fourth wall
    for i = x
        for k = z
            flux_wall_4 = flux_wall_4 + (D *
dot(gradu(i,ymax,k,t(n),D,alpha),normal_4) * hx * hz );
        end
    end

    % Summation of the flux of the walls
    phi(n) = flux_wall_1 + flux_wall_2 + flux_wall_3 + flux_wall_4;
%-----------------------------------------------------------------------

end

% % Plotting the figure
figure(1)
plot(t,phi,'r')
plot(t,zeros(length(t),1),'k')

% Labelling the figure
% Including the legend
legend("ρ(t)", "Φ(t)");
hold off
```

Screenshot of the Code

Editor - C:\Users\User\OneDrive\Desktop\ENG2005\Assignment 2\Assignment2_32194471.m

Assignment2_32194471.m

```
% Written by Tan Jin Chun (32194471)
% Last Modified: 23/4/2022
% Assignment 2 Question 2

clc;clear;close all

% Given variables and equations
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alpha = 1;
u = @(x,y,z,t,D,alpha) 1/(4*pi*D*t) * exp(-(x^2+y^2)/(4*D*t) - alpha*z/D);

% Modified Section
% You will need a function which returns the grad of u -- it is a vector.
gradu = @(x,y,z,t,D,alpha) [(-x/(2*D*t))*u(x,y,z,t,D,alpha); ...
(-y/(2*D*t))*u(x,y,z,t,D,alpha); ...
 (-alpha/D)*u(x,y,z,t,D,alpha)];
% ---------------------------------------------------------------------

% My ID is 32194471
% 50 intervals in each dimension of the room to discretise the room
N = 50;

% The boundary conditions for x, y and z
xmin = 1; %last number in ID
xmax = xmin+2;
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```
x = linspace(xmin,xmax,N+1);
hx = x(2)-x(1);
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ymax = ymin+3;
y = linspace(ymin,ymax,N+1);
hy = y(2)-y(1);
zmin = 0;
zmax = 3;
z = linspace(zmin,zmax,N+1);
hz = z(2)-z(1);

x = x(1:end-1)+hx/2;
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tmin = 0;
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t = linspace(tmin,tmax,Nt+1); t = t(2:end);

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rho = zeros(Nt,1);

for n = 1:Nt

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    % First, we would need to initialise the value of total mass of smoke
    tot_mass_smoke = 0;

    % We will be using three for loops here to approximate the total mass
    % of smoke at any moment of time (basically using the summation formula
    % shown in the assignment 2 notes)
    for i = x
        for j = y
            for k = z
                tot_mass_smoke = tot_mass_smoke + (u(i,j,k,t(n),D,alpha) * hx * hy * hz);
            end
        end
    end

    % Assigning the value to rho before zeroing it to update the value
    rho(n) = tot_mass_smoke;
```

```

end

%-----------------------------------------------------------------------

% Plotting the figure
figure(1)
cla
plot(t,rho)
hold on

% % Plotting the line where the smoke detection in the living room activates
% % if the total smoke mass in the living room, p is larger than 0.015
% yline(0.015,'g');

% Labelling the figure
xlabel("t");
ylabel("rho(t), phi(t)");
title("Plot of rho(t) and phi(t) against t");

```

```matlab
%% ---- Flux (Part b)-----------------------------------------------------
% Initialising the value of phi
phi = zeros(Nt,1);

for n = 1:Nt

    %Calculate the flux integral at time t(n) and enter it as the value
    %phi(n)

% Modified Section-------------------------------------------------------

    % We can calculate the flux for each separate wall with the formula
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    % Initialising the variables for the flux of the wall
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```

```matlab

    % The first wall
    for j = y
        for k = z
            flux_wall_1 = flux_wall_1 + (D * dot(gradu(xmin,j,k,t(n),D,alpha),normal_1) * hy * hz );
        end
    end

    % The second wall
    for i = x
        for k = z
            flux_wall_2 = flux_wall_2 + (D * dot(gradu(i,ymin,k,t(n),D,alpha),normal_2) * hx * hz );
        end
    end

    % The third wall
    for j = y
        for k = z
            flux_wall_3 = flux_wall_3 + (D * dot(gradu(xmax,j,k,t(n),D,alpha),normal_3) * hy * hz );
        end
    end

    % The fourth wall
    for i = x
```

```
    % The fourth wall
    for i = x
        for k = z
            flux_wall_4 = flux_wall_4 + (D * dot(gradu(i,ymax,k,t(n),D,alpha),normal_4) * hx * hz );
        end
    end

    % Summation of the flux of the walls
    phi(n) = flux_wall_1 + flux_wall_2 + flux_wall_3 + flux_wall_4;
%---------------------------------------------------------------------------

end

% % Plotting the figure
figure(1)
plot(t,phi,'r')
plot(t,zeros(length(t),1),'k')

% Labelling the figure
% Including the legend
legend("ρ(t)", "Φ(t)");
hold off
```