Task 1 a)

$$\boxed{y(t) = \int_{-\infty}^{t} x(\lambda)\, d\lambda}$$

Practise 1

$$y(t) = y(0) + \int_0^t x(\lambda)\, d\lambda$$
$$= 0 + \int_0^t x(\lambda)\, d\lambda$$
$$= \int_0^t \sin 2\pi\lambda \, d\lambda$$
$$= \frac{-1}{2\pi}\left[\cos 2\pi\lambda\right]_0^t$$
$$= \frac{-1}{2\pi}\left[\cos 2\pi t - 1\right]$$
$$= \boxed{\tfrac{1}{2\pi}(1-\cos 2\pi t)}$$

Task 1 b)

```
syms A f0 t pi
xt = A*sin(2*pi*f0*t);
yt = int(xt,'t')
```

yt =

$$-\frac{A\cos(2\, f_0\, \pi\, t)}{2\, f_0\, \pi}$$

```
yt = int(xt,'t',[0,t])
```

yt =

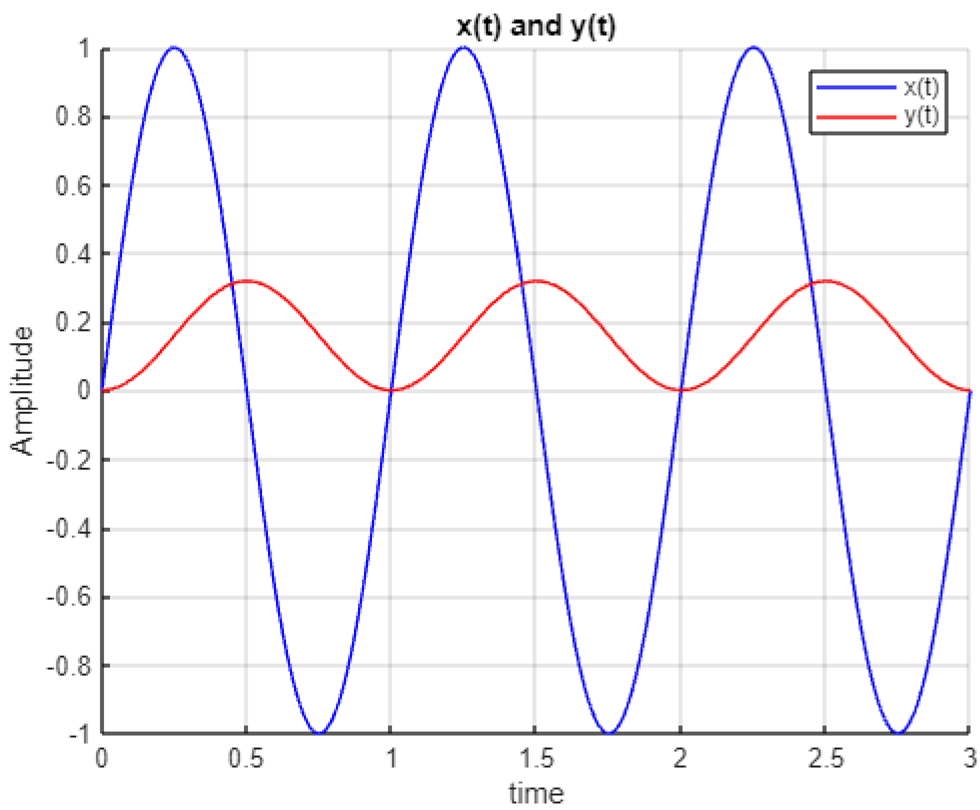
$$\frac{A\sin(f_0\, \pi\, t)^2}{f_0\, \pi}$$

```
% yes this result is the same as the one I did by hand.
% expanding using the double angle identity gives the exact same result
```

Task 1 c)

```
t = 0:0.01:3;
A = 1; f0 = 1;
xt = A*sin(2*pi*f0*t);
yt = ((A*sin(f0*pi*t)) .^ 2) / (f0*pi);

figure;
hold on;
grid on;
```

```
plot(t, xt, "b");
plot(t, yt, "r");

xlabel("time");
ylabel("Amplitude");
title("x(t) and y(t)");
legend("x(t)", "y(t)");
```



Task 1 d)

```
a = [1 2 3 4 5];
b = cumsum(a)
```

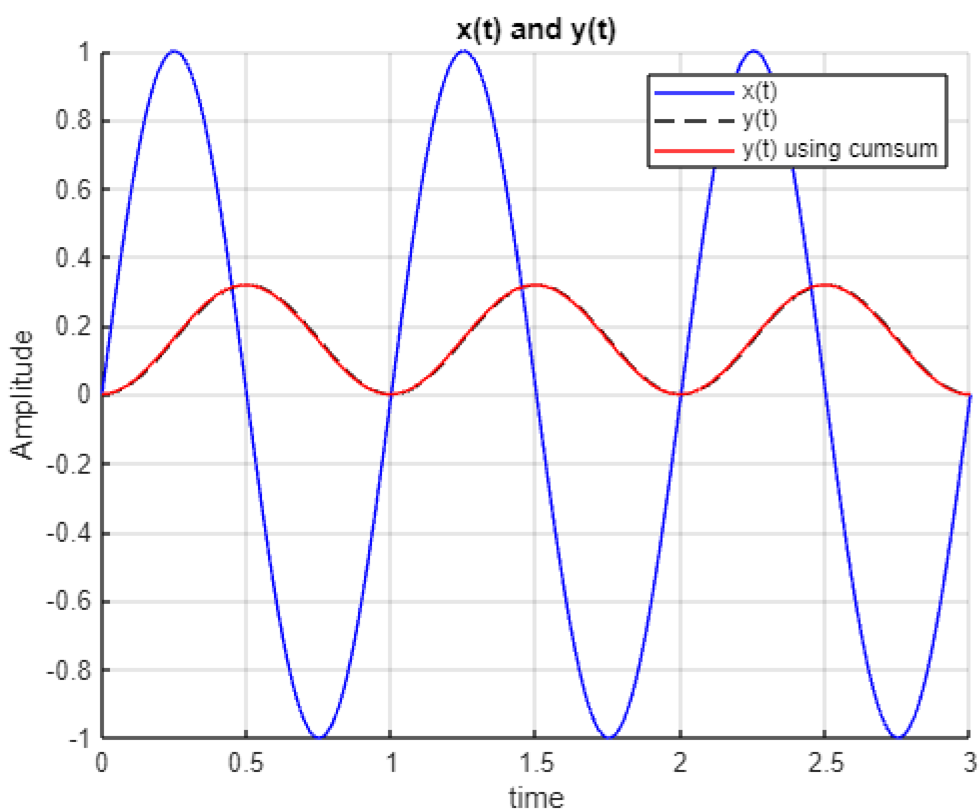
```
b = 1×5
     1     3     6    10    15
```

```
% b_i = sum of all elements from b_1 to b_i
```

Task 1 e) and f)

```
dt = 0.01;
t = 0:dt:3;
A = 1; f0 = 1;
xt = A*sin(2*pi*f0*t);
yt = ((A*sin(f0*pi*t)) .^ 2) / (f0*pi);
```

```
yt_cs = cumsum(xt) * dt;

figure;
hold on;
grid on;

plot(t, xt, "b");
plot(t, yt, "black--");
plot(t, yt_cs, "red");

xlabel("time");
ylabel("Amplitude");
title("x(t) and y(t)");
legend("x(t)", "y(t)", "y(t) using cumsum");
```



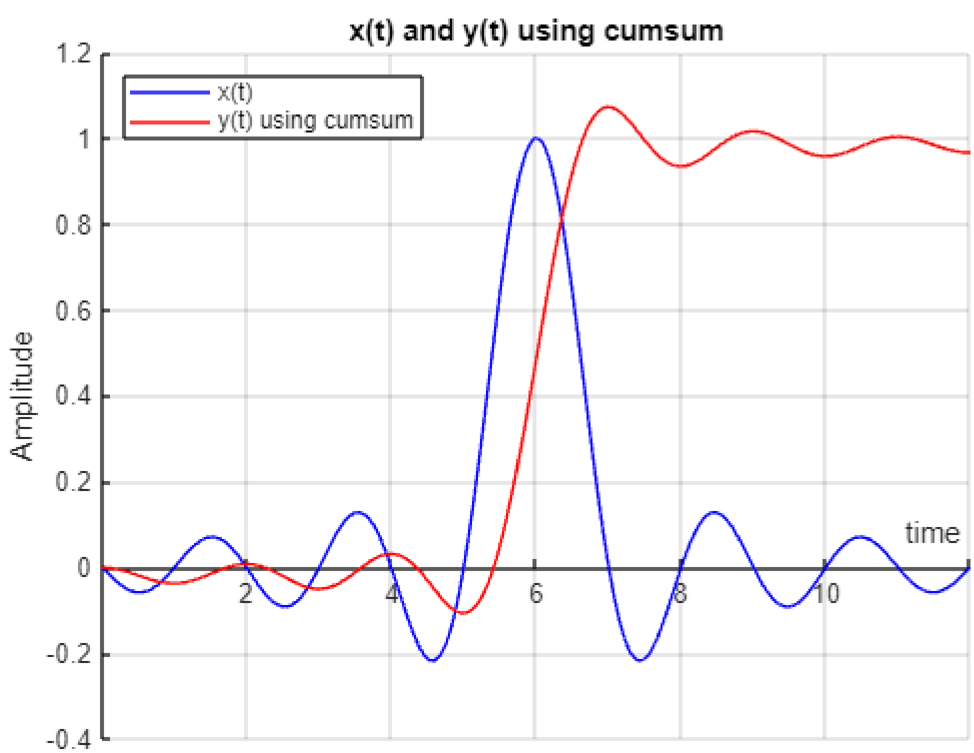

```
% It is almost same as the graph of the integrated function
```

Task 1 g)

Numerical integration is useful in real-world situations where we deal with data points instead of a clear formula. It is easier and faster for solving complex problems where exact solutions are hard to find. It works well with noisy or messy data, handles high-dimensional problems, and is used in real-time applications like signal processing. It’s simple to use and very helpful in fields like engineering and science.

Task 1 h)

```
dt = 0.01;
t = 0:dt:12;
xt = sinc(t-6);
yt = cumsum(xt) * dt;

figure;
hold on;
grid on;

plot(t, xt, "b");
plot(t, yt, "r");

xlabel("time");
ylabel("Amplitude");
title("x(t) and y(t) using cumsum");
legend(["x(t)", "y(t) using cumsum"], "location", "northwest")
ax = gca; % Get current axes
ax.XAxisLocation = 'origin';
```



Task 1 i)

```
a = [1 2 3 4 5];
b = diff(a)
```

```
b = 1×4
     1     1     1     1
```

```
% a_i = a_(i+1) - a_i
```

Task 1 j)

$$y(t) = 2te^{-t}$$

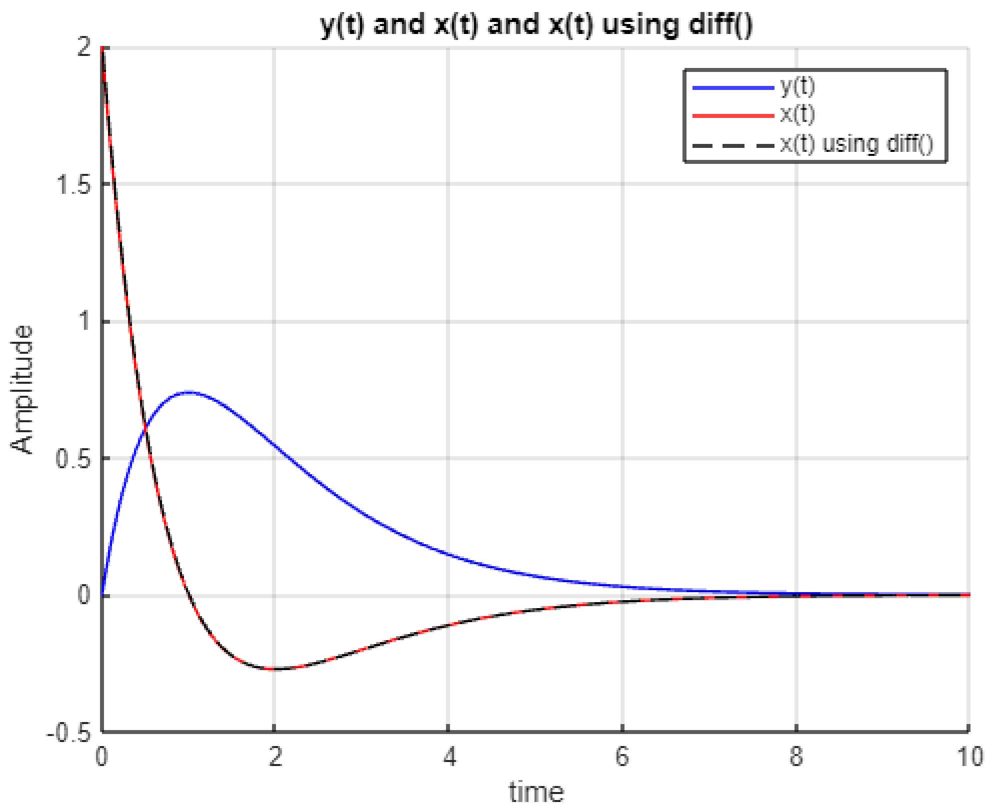
$$x(t) = d\,y(t)/dt$$

$$= 2t(-e^{-t}) + 2(e^{-t})$$

$$= 2e^{-t}(1-t)$$

Task 1 k) and l)

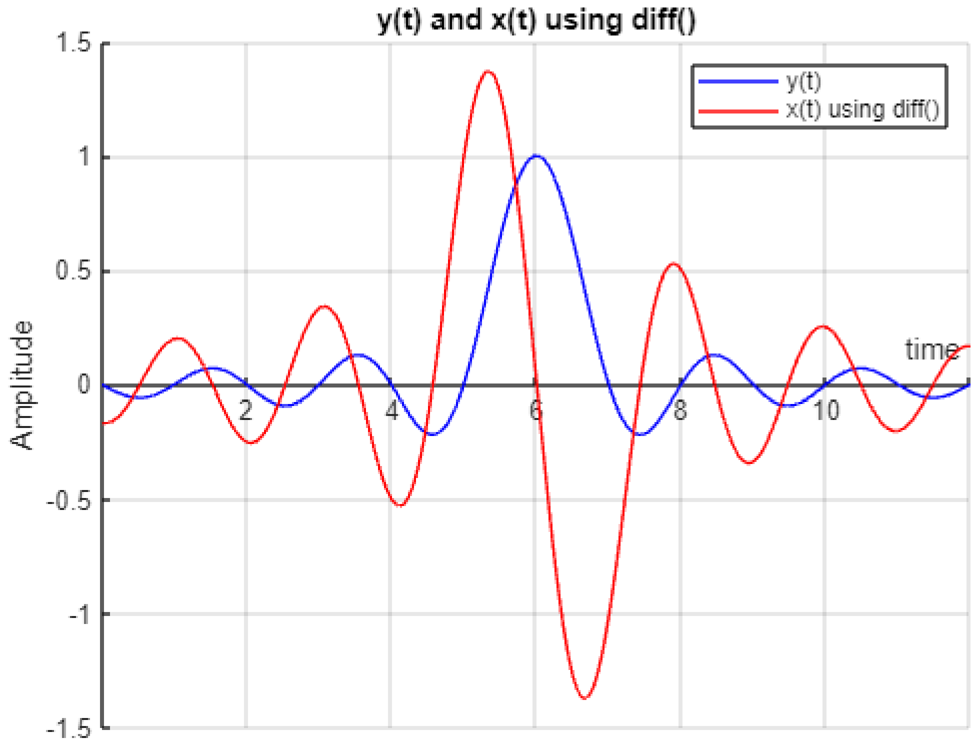
```
dt = 0.01;
t = 0:dt:10;
yt = 2 * t .* exp(-1* t);
xt = 2 * exp(-t) .* (1-t);
xt_df = [nan diff(yt)/dt];

figure;
hold on;
grid on;

plot(t, yt, "b");
plot(t, xt, "r");
plot(t, xt_df, "black--");

xlabel("time");
ylabel("Amplitude");
title("y(t) and x(t) and x(t) using diff()");
legend("y(t)", "x(t)", "x(t) using diff()");
```




```
% It is the same as the differentiated function
```

Task 1 m)

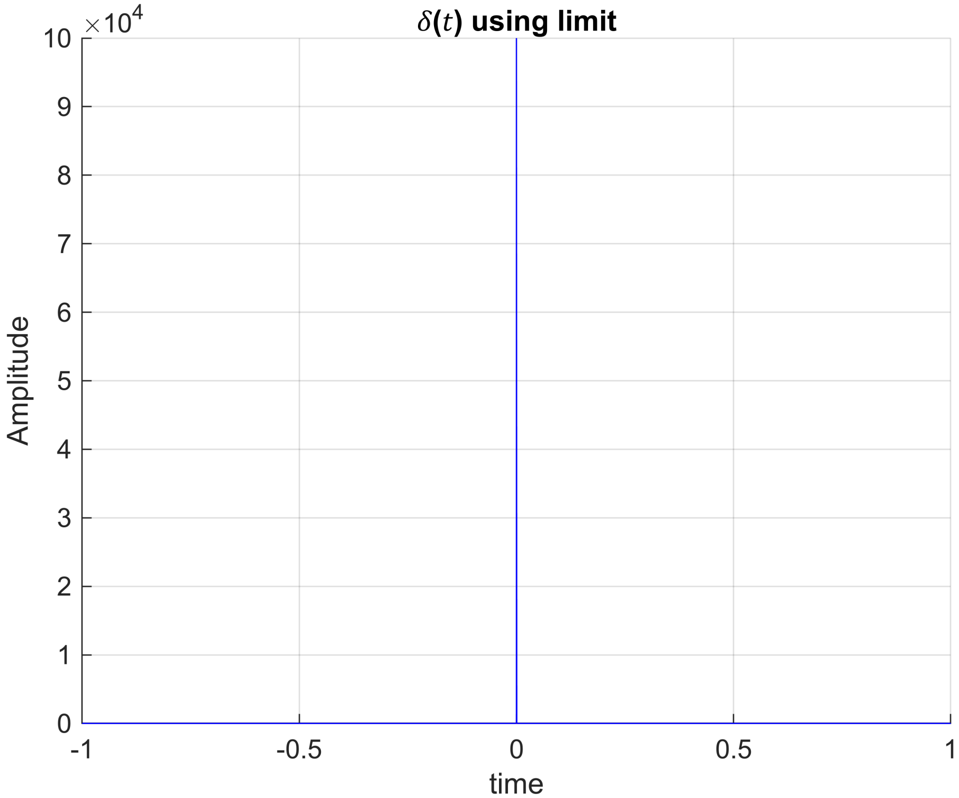
```
dt = 0.01;
t = 0:dt:12;
yt = sinc(t-6);
xt_df = [nan diff(yt)/dt];

figure;
hold on;
grid on;

plot(t, yt, "b");
plot(t, xt_df, "red");

xlabel("time");
ylabel("Amplitude");
title("y(t) and x(t) using diff()");
legend("y(t)","x(t) using diff()");
ax = gca; % Get current axes
ax.XAxisLocation = 'origin';
```



POST LAB

Task 1 n)

```
a = 0.00001;
dt = 0.00001;
t = -1:dt:1;
deltat = (a ./ ((pi * t).^2)) .* (sin(pi * t / a).^2);
deltat(t == 0) = 1 / a;

grid on;

plot(t, deltat, "b");
xlabel("time");
ylabel("Amplitude");
title("�(�) using limit");
```



Task 1 o)

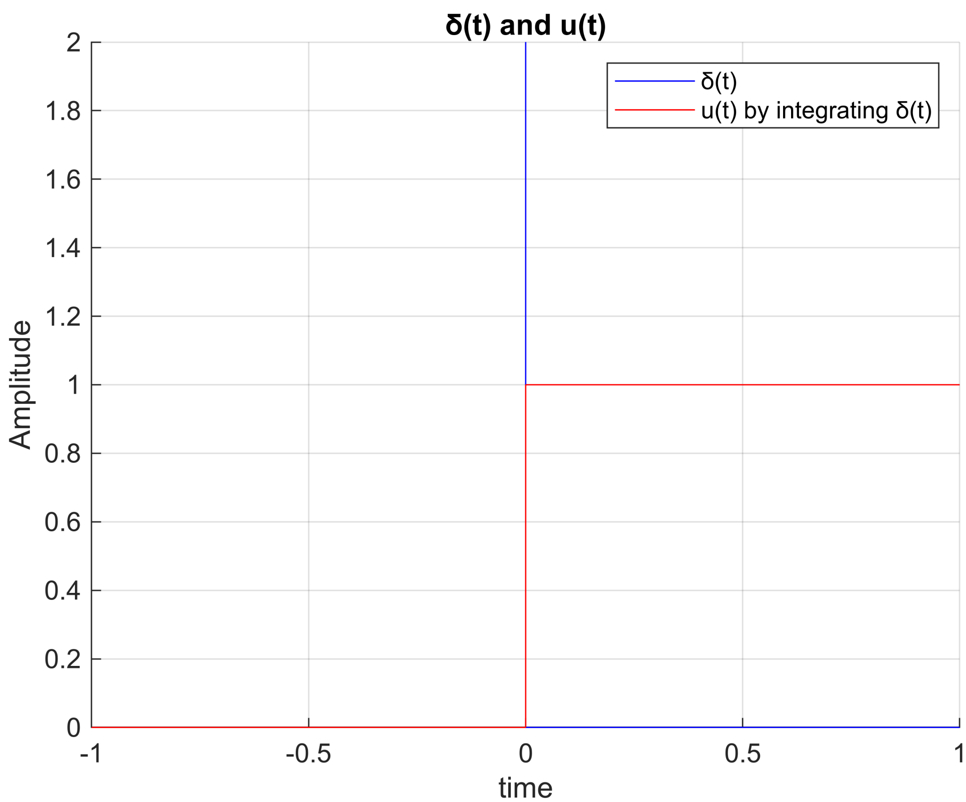
```
a = 0.00001;
dt = 0.00001;
t = -1:dt:1;
deltat = (a ./ ((pi * t).^2)) .* (sin(pi * t / a).^2);
deltat(t == 0) = 1 / a;

area = sum(deltat) * dt
```

```
area =
1.0000
```

Task 1 p)

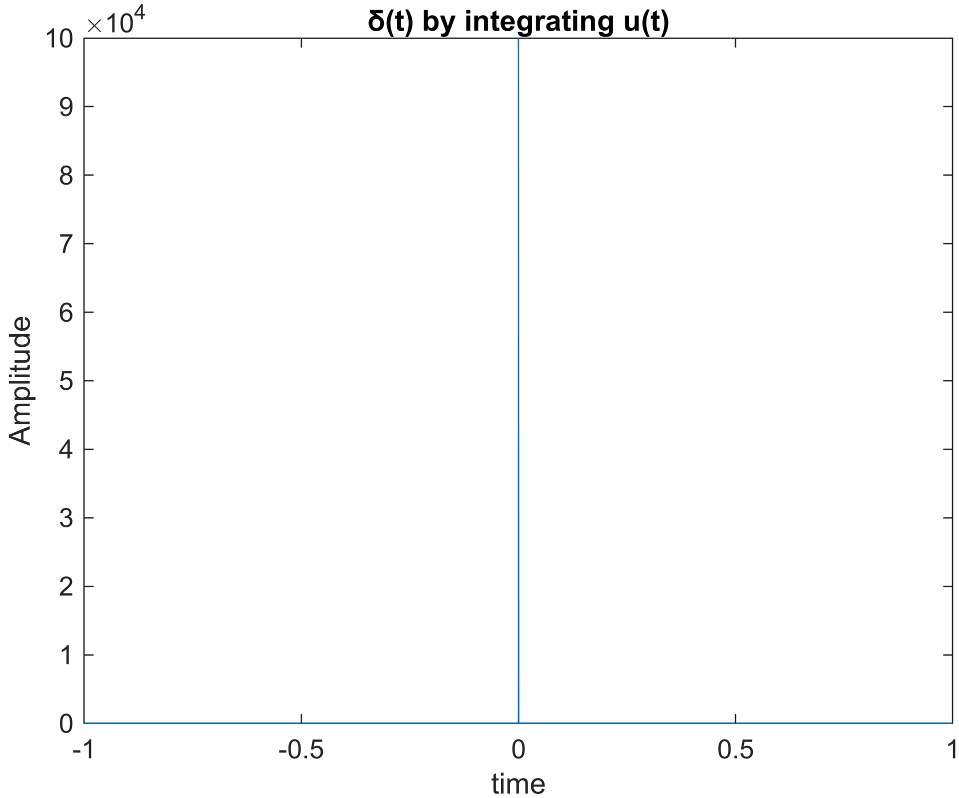
```
a = 0.00001;
dt = 0.00001;
t = -1:dt:1;
deltat = (a ./ ((pi * t).^2)) .* (sin(pi * t / a).^2);
deltat(t == 0) = 1 / a;

ut = cumsum(deltat) * dt;

figure;
hold on;
```

```
grid on;

plot(t, deltat, "b");
plot(t, ut, "red");

xlabel("time");
ylabel("Amplitude");
title("δ(t) and u(t)");
legend("δ(t)","u(t) by integrating δ(t)");
axis([-1, 1, 0, 2]);
```



Task 1 q)

```
dt = 0.00001;
t = -1:dt:1;
ut = t>=0;
deltat = [nan diff(ut) / dt];
plot(t, deltat);
xlabel("time");
ylabel("Amplitude");
title("δ(t) by integrating u(t)");
```


δ(t) by integrating u(t)
×10^4
10
9
8
7
6
5
4
3
2
1
0
Amplitude
-1
-0.5
0
0.5
1
time