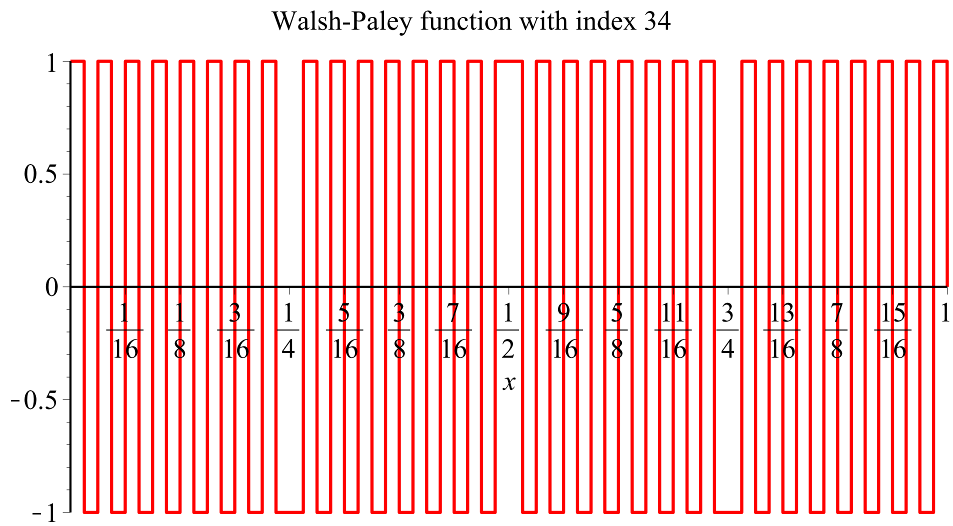
First, create the directory "C:\Maple\lib" and open the file "WalshPaleyModule.mw" with Maple 17 or later version.
After running "WalshPaleyModule.mw" the package file "WalshPaleyModule.m" is created in the directory.
Create a new Maple worksheet and type the following commands.

```
> restart:
  libname:="C:\\Maple\\lib",libname:
  with(WalshPaley);
```

[*AddValues*, *CesaroMFunc*, *CesaroMVal*, *DiriFunc*, *DiriVal*, *FCoeff*, *FCoeffs*, *FSumFunc*, *FSumVal*, *FSumsVal*, *FejerMFunc*, *FejerMVal*, *FejerMsVal*, *GetDim*, *GetHadamard*, *IntValues*, *J*, *KCFunc*, *KCVal*, *KFunc*, *KNorm*, *KVal*, *LebConst*, *NormValues*, *ProdValues*, *SFunc*, *SVal*, *SetDim*, *SumFunc*, *SumVal*, *WalshPFunc*, *WalshPTriangFunc*, *WalshPVal*, *lineplot*, *lineplot3d*] **(1)**

Command **with(WalshPaley)** loads the package and at the start we are able to use the Walsh-paley functions up to the index 2^6-1=63.
The function **WalshPFunc(n,x)** gives us the value of the Walsh-Paley function with index **n** at the point **x**.
Plot the Walsh-Paley function with index 34.

```
> plot(WalshPFunc(34,x),x=0..1,title=cat("Walsh-Paley function with
  index 34"),color="red",tickmarks=[[seq(i/16=i/16,i=1..16)],
  default]);
```



At this time we can not use system functions with indices greater than 63.
Find the value of the Walsh-Paley function with index 70 at the point 0.3.

```
> WalshPFunc(70,0.3);
```

70, "The specified value exceeds the current dimension, this should be less than", 64 **(2)**

To obtain the value above we have to set up the dimension (the number of generated system functions) in the module, because the current dimension is only 2^6=64.
With the command **SetDim(m)** we can set de dimension to the value 2^m.

```
> SetDim(10):
  WalshPFunc(70,0.3);
```

(3)

$$-1 \quad (3)$$

The command **`GetDim()`** gives us the value of the current dimension.

```
> GetDim();
```

$$1024 \quad (4)$$

The dimension is essential for the functioning of the package WalshPaley.
The command **SetDim(m)** generates the list of Hadamard matrices of size 2^k with respect to the Walsh-Paley system, where k is from 0 up to **m**.
The entry with indeces i and j of the Hadamard matrices of size 2^k with respect to the Walsh-Paley system is the value of the Walsh-Paley function with index i-1 at the point (j-1)/2^k.
The command **GetHadamard(k)** gives us the Hadamard matrices of size 2^k with respect to the Walsh-Paley system.
Get the Hadamard matrix of size 16 with respect to the Walsh-Paley system.

```
> interface(rtablesize=16):#this command allows us to show matrices and vectors of large size.
  GetHadamard(4);
```

$$\left[\begin{array}{cccccccccccccccc}
1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\
1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 \\
1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\
1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & 1 & 1 & 1 & 1 \\
1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 \\
1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 & 1 \\
1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 \\
1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 & 1 & 1 & 1 & -1 & -1 \\
1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 \\
1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 & 1 \\
1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 \\
1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 & 1 & 1 & -1 & 1 & -1 \\
1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\
1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 & -1 & 1 & 1 & -1 \\
1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 \\
1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 & -1 & 1 & 1 & -1 & 1 & -1 & -1 & 1
\end{array}\right] \qquad (5)$$

The command **WalshPVal(n)** gives us a row vector with the values of the Walsh-Paley function with index **n** at the dyadic intervals [(i-1)/2^k, i/2^k[, where 2^(k-1)<=n<2^k.
The size of the vector **WalshPVal(n)** is appropriate to the value of **n**, and not to the current dimension.
Get the vector **WalshPVal(n)** for n=5 and n=13.

```
> WalshPVal(5);WalshPVal(13);
```

$$\left[\begin{array}{cccccccc} 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 \end{array}\right]$$

$$\left[\begin{array}{cccccccccccccccc} 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 & -1 & 1 & 1 & -1 \end{array}\right] \qquad (6)$$

When considering step functions as a vector we greatly speed up the calculations.
Some procedures use this new approach, for intance to calculate the integral and the Lp-norm.

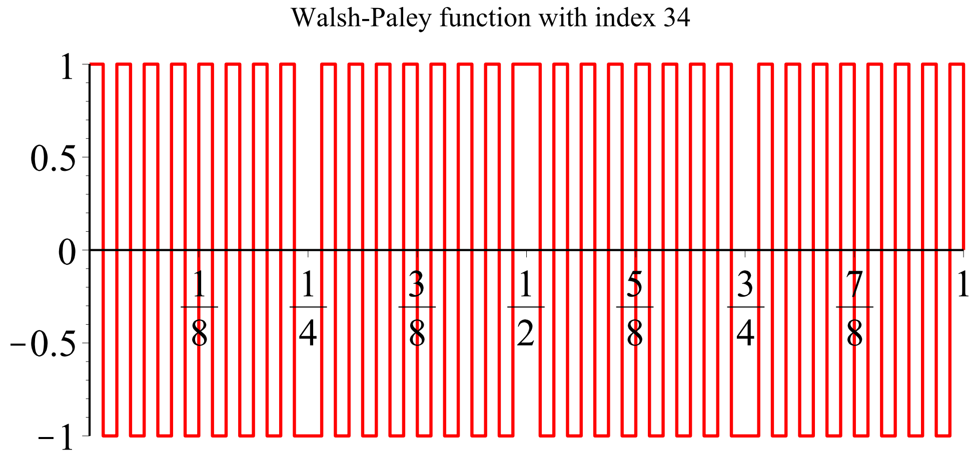
Calculate the integral the L1-norm and the L2-norm of and the Walsh-Paley function with index 40.

```
> IntValues(WalshPVal(40));NormValues(WalshPVal(40));NormValues[2](WalshPVal(40));
```

$$0$$
$$1$$
$$1 \quad (7)$$

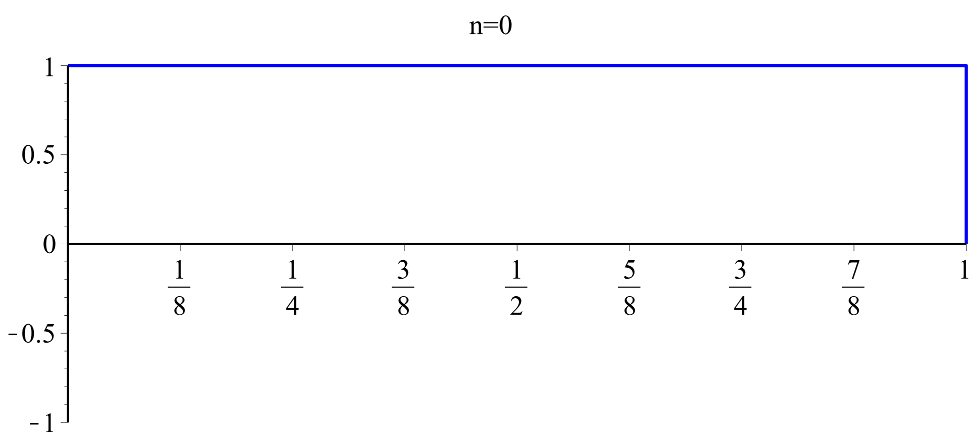
The procedure **lineplot** is able to plot step functions with the vector of its values.
Plot the Walsh-Paley function with index 34

```
> lineplot(WalshPVal(34),title=cat("Walsh-Paley function with index 34"),color="red",tickmarks=[[seq(i/8=i/8,i=1..8)],default],axesfont=[TIMES,ROMAN,14],tozero);
```



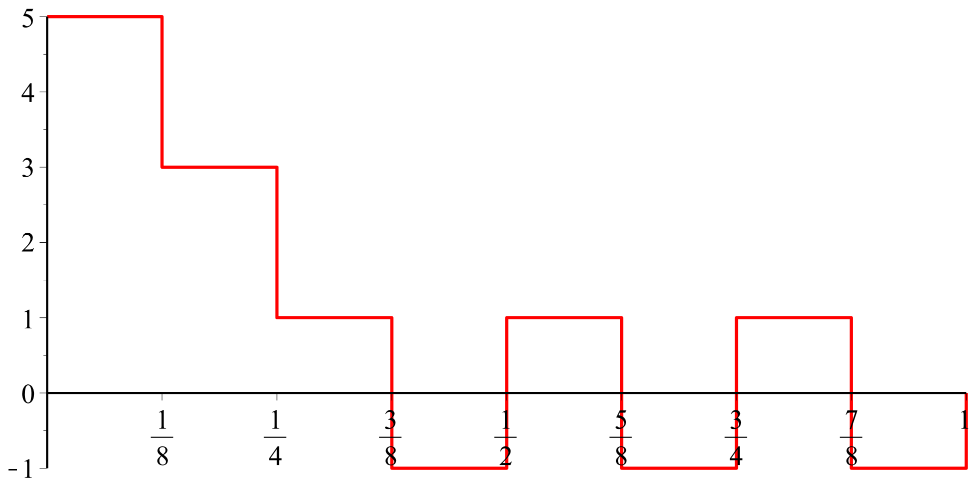
The following animation shows the effectiveness of the new approach.

```
> SetDim(9):
plots[display](seq(lineplot(WalshPVal(n),tozero,title=cat("n=",n),color="blue", tickmarks=[[seq(i/8=i/8,i=1..8)],default]), n=0..511), insequence=true);
```



The command **SumVal(sor)** gives us a row vector with the values of the linear combination of the first system functions with the nunbers in the list **sor**.
This linear combination is called a Walsh polynomial with respect to the Walsh-Paley sytem.
With the option **floating** the command numerically evaluates all expressions, thus it makes the calculations faster.
The procedure **SumFunc(sor,x)** makes a function with the values of **SumVal(sor)**.
Plot the first 5 Walsh-Paley functions and list its values.

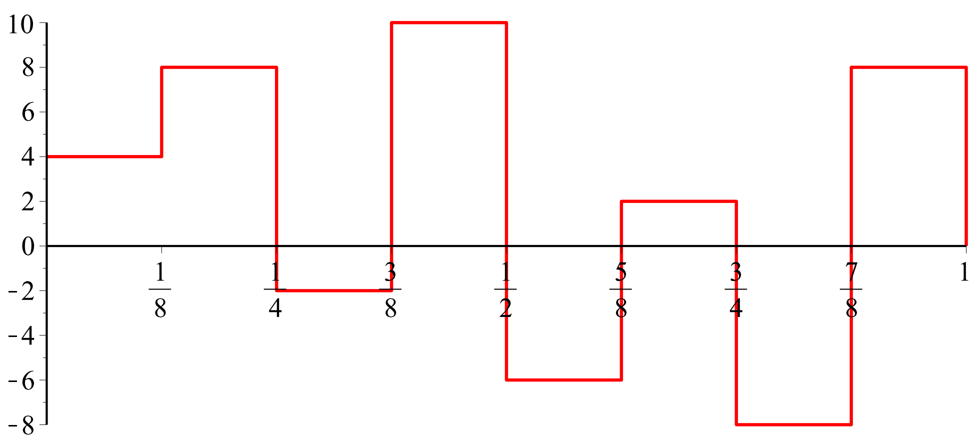
```
> lineplot(SumVal([1,1,1,1,1]),color="red",tickmarks=[[seq(i/8=i/8,
  i=1..8)],default],tozero);
  SumVal([1,1,1,1,1]);
```



$$\begin{bmatrix} 5 & 3 & 1 & -1 & 1 & -1 & 1 & -1 \end{bmatrix} \quad (8)$$

Plot the Walsh polynomial with coefficients 2,3,0,1,-5,1,2 and list its values.

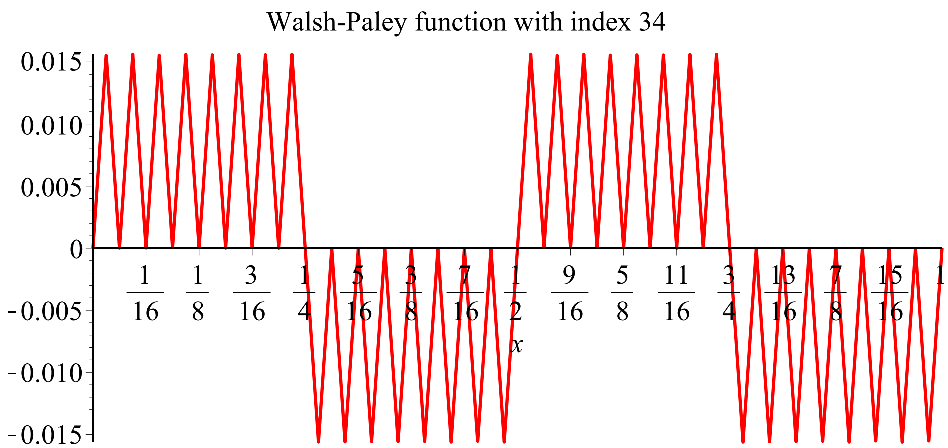
```
> lineplot(SumVal([2,3,0,1,-5,1,2]),color="red",tickmarks=[[seq
  (i/8=i/8,i=1..8)],default],tozero);
  SumVal([2,3,0,1,-5,1,2]);
```



$$\begin{bmatrix} 4 & 8 & -2 & 10 & -6 & 2 & -8 & 8 \end{bmatrix} \quad (9)$$

Triangular functions are the integral functions of the Walsh-Paley functions.
The function **WalshPTriangFunc(n,x)** gives us the value of the triangular function with index **n** at the point **x**.
Plot the triangular function with index 34.

```
> plot(WalshPTriangFunc(34,x),x=0..1,title=cat("Walsh-Paley
  function with index 34"),color="red",numpoints=2000,tickmarks=[
  [seq(i/16=i/16,i=1..16)],default]);
```



The matrix of the Fourier-coefficients of triangular functions is obtained as follows:

```
> J(3);
```

$$\begin{bmatrix} \frac{1}{2} & -\frac{1}{4} & -\frac{1}{8} & 0 & -\frac{1}{16} & 0 & 0 & 0 \\ \frac{1}{4} & 0 & 0 & -\frac{1}{8} & 0 & -\frac{1}{16} & 0 & 0 \\ \frac{1}{8} & 0 & 0 & 0 & 0 & 0 & -\frac{1}{16} & 0 \\ 0 & \frac{1}{8} & 0 & 0 & 0 & 0 & 0 & -\frac{1}{16} \\ \frac{1}{16} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \frac{1}{16} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \frac{1}{16} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{1}{16} & 0 & 0 & 0 & 0 \end{bmatrix} \quad \textbf{(10)}$$