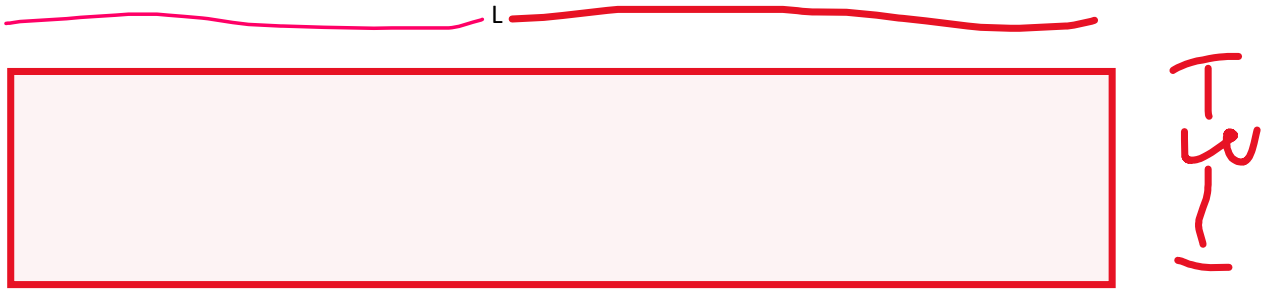
Box optimization

How to make a box

Take a cardboard of length l & width w centimeters as shown in figure-1

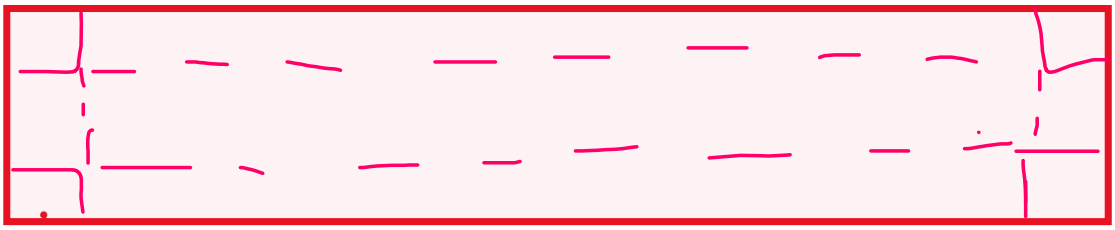



Cut four squares from the edges of the box of h-by-h centimeters each corner. Remove these four squares as wastages & fold along the side to make a box of

length l-2*h,

width w-2*h &

height h centimeters as shown in figure-2



Problem narration

You are requested to make a box from a cardboard of suitable dimensions, having

1. a volume of 35000 cm3 with a margin (for explanations on margin see annexure-1) of 3%.
2. Business requirements imposes following additional constraints.
3. Length to width ratio for the box must be 2 with margin of 5 %.
4. Length to height ratio of the box must be 10 with margin of 15%
5. Minimum height of 10 cm is required.
6. Length & width of the cardboard used must be an integer.
7. Height cut from this cardboard must also be an integer.

I use lingo software for solving this problem.

Lingo code for solving this problem is pasted here.

```
model:
data:
vreq=35000;
mrgn1=3;
mrgn2=5;
mrgn3=15;
lwr=2;
lhr=10;
hmin=10;
enddata
v11=vreq*(1-mrgn1/100);
v12=vreq*(1+mrgn1/100);
v21=lwr*(1-mrgn2/100);
v22=lwr*(1+mrgn2/100);
v31=lhr*(1-mrgn3/100);
v32=lhr*(1+mrgn3/100);
```

```
el=l-2*h;
ew=w-2*h;
eh=h;

ev=el*ew*eh;
ev>=v11;
ev<=v12;
elwr=el/ew;
elwr>=v21;
elwr<=v22;
elhr=el/eh;
elhr>=v31;
elhr<=v32;
eh>=hmin;

wstg=4*h^2*100/(l*w);
min=wstg;

 @gin(l);@gin(w);@gin(h);

end
Global optimal solution found.
  Objective value:                              6.144393
  Objective bound:                              6.144393
  Infeasibilities:                              0.000000
  Extended solver steps:                               1
  Total solver iterations:                            54
  Elapsed runtime seconds:                          0.05

  Model Class:                                     MINLP

  Total variables:                    10
  Nonlinear variables:                 6
  Integer variables:                   3

  Total constraints:                  15
  Nonlinear constraints:               4

  Total nonzeros:                     30
  Nonlinear nonzeros:                 10



                             Variable           Value        Reduced
Cost
                                 VREQ        35000.00
0.000000
                                MRGN1        3.000000
0.000000
                                MRGN2        5.000000
0.000000
                                MRGN3        15.00000
0.000000
                                  LWR        2.000000
0.000000
                                  LHR        10.00000
0.000000
                                 HMIN        10.00000
0.000000
```

| | | |
|---|---|---|
| 0.000000 | V11 | 33950.00 |
| 0.000000 | V12 | 36050.00 |
| 0.000000 | V21 | 1.900000 |
| 0.000000 | V22 | 2.100000 |
| 0.000000 | V31 | 8.500000 |
| 0.000000 | V32 | 11.50000 |
| 0.000000 | EL | 85.00000 |
| 0.5851803E-01 | L | 105.0000 - |
| 1.228879 | H | 10.00000 |
| 0.000000 | EW | 42.00000 |
| 0.9910312E-01 | W | 62.00000 - |
| 0.000000 | EH | 10.00000 |
| 0.000000 | EV | 35700.00 |
| 0.000000 | ELWR | 2.023810 |
| 0.000000 | ELHR | 8.500000 |
| 0.000000 | WSTG | 6.144393 |

Solution suggest that you need to take cardboard dimensions as

L=105 & w=62 cms.

Cut height of 10 cms.

Fold it to make the box which will have volume of 35700.00 cm3 effective length/width ratio= 2.023810

Effective length to height ratio= 8.500000

Height is equal to 10 cms.

All are in integers

With this configuration your wastage will be of 6.144393 % which is relatively higher but it is the minimum. any other combination will give wastage % higher than this.

Annexure-1

margin

What is margin?

If v is the value required & m is the margin in then acceptable values are in between v*(1-m/100) & v*(1+m/100)

If volume of the box required is 35000 cm3 with a margin of 5 % means acceptable volumes are in between 33250 & 36750 cm3