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How to calculate the Center of Gravity

Introduction

There are n load cells: LC1, …, LCn.
The illustrations below describe systems with 2, 3 or 4 load cells.
However, the formulas used are general for n >= 2.
All the n load cells are calibrated the same.
There is some **reference point** that serves as the **origin** of the X,Y axes.

Notations

The 'i' index in all the expressions below goes from 1 to n (e.g., for n=3: i = 1, 2, 3).

LCi = Load Cell #i.
(Xi,Yi) = The position of LCi.
Wi = The weight reading of LCi.
Wt = total weight = sum of all Wi.
(Xcg,Ycg) = The position of the CoG (Center of Gravity).
MXi = The X-Moment of LCi = Wi*Xi.
MYi = The Y-Moment of LCi = Wi*Yi.

MXt = The **total** X-Moment = sum of all MXi = Wt*Xcg
MYt = The **total** Y-Moment = sum of all MYi = Wt*Ycg

Xcg = MXt / Wt
Ycg = MYt / Wt

Application

Given (input)

1. Weight units (e.g., kg).
2. Length units (e.g., cm).
3. **Position** report's format:
   # of digits after the decimal point for the **CoG X/Y position** (e.g., 2).
4. **Weight** report's format:
   # of digits after the decimal point for the **CoG weight** (e.g., 0).
5. n (e.g., 3).
6. **Weight** (Wi) and **position** (Xi, Yi) of all load cells.
   Note: You may specify the weight & position in **free format**. That is, you are not subject to the formats defined in paragraphs 3 & 4: The effect of these formats is only on application's **output**.

Notes

*** You may set the "input" of the application to any of the following 6 examples:
Select the corresponding serial # (01 → 06) in application's "Example" field.**

*** Changing the position (X and/or Y) of a load cell might throw its location out of graph limits. Therefore, it is recommended to click "Graph Settings" after changing load cell's position, and verify that graph limits are OK. However, in case a load cell exceeds the limits, the application gives a proper message.**

*** The application keeps the input of the last report or graph –
next time you run, this input will be used automatically.**

Output

Click "Report / Graph" in order to Switch between Report & Graph.

1. Report

1. Date & Time.
2. Formatted presentation of the input (**weights** and **positions**).
3. Total Weight (Wt).
4. Center of Gravity coordinates (Xcg, Ycg).

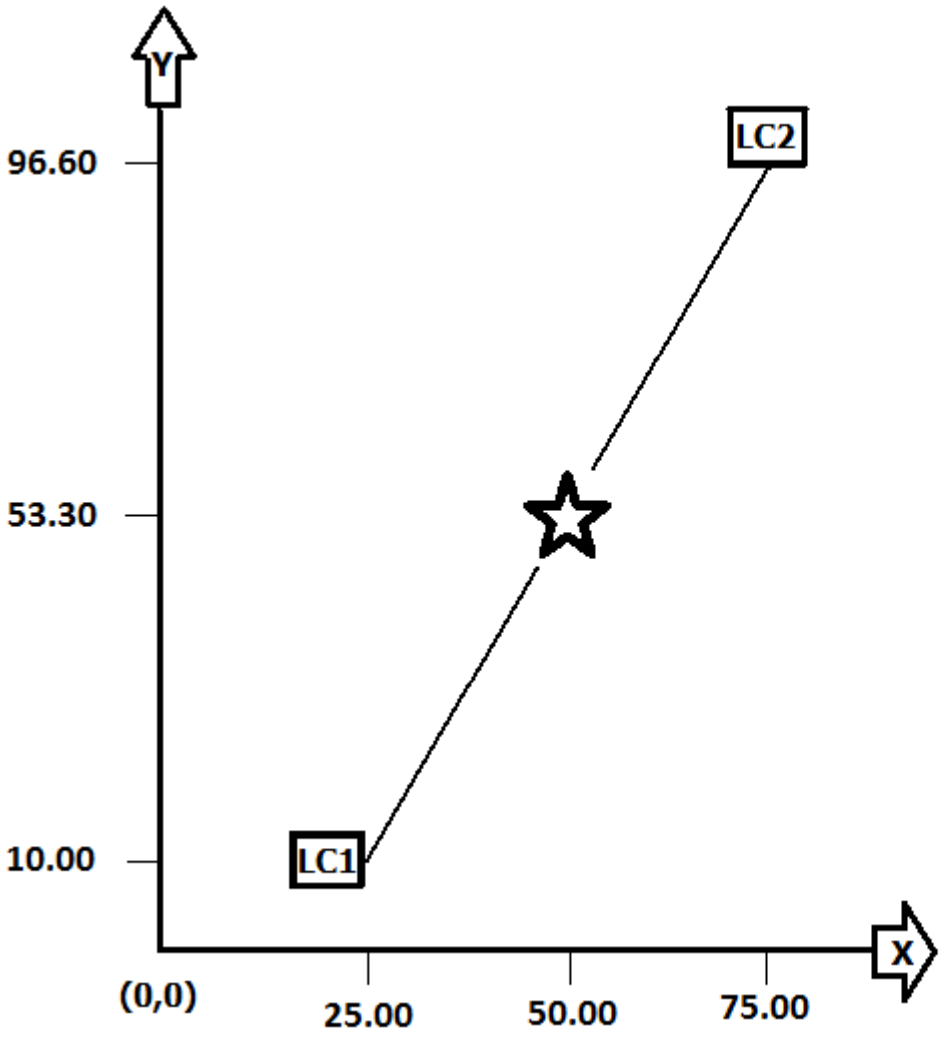
2. Graph

Graphical presentation of the report.

Example #1

This example shows a **2 load cells system**.
The load cells are positioned at the 2 edges of a 100 cm line.
In this example object's CoG is in line's center.

The illustration below shows the system. The CoG is marked by a star.


Y
96.60
53.30
10.00
LC2
LC1
X
(0,0)
25.00
50.00
75.00

Given

1. Weight units: kg
2. Length units: cm
3. Position report's format: # of digits after the decimal point for the **CoG X/Y position**: 2
4. Weight report's format: # of digits after the decimal point for the **CoG weight**: 0
5. n: 2
6.

```
W1 = 20,    X1 = 25,    Y1 = 10.
W2 = 20,    X2 = 75,    Y2 = 96.6.
```

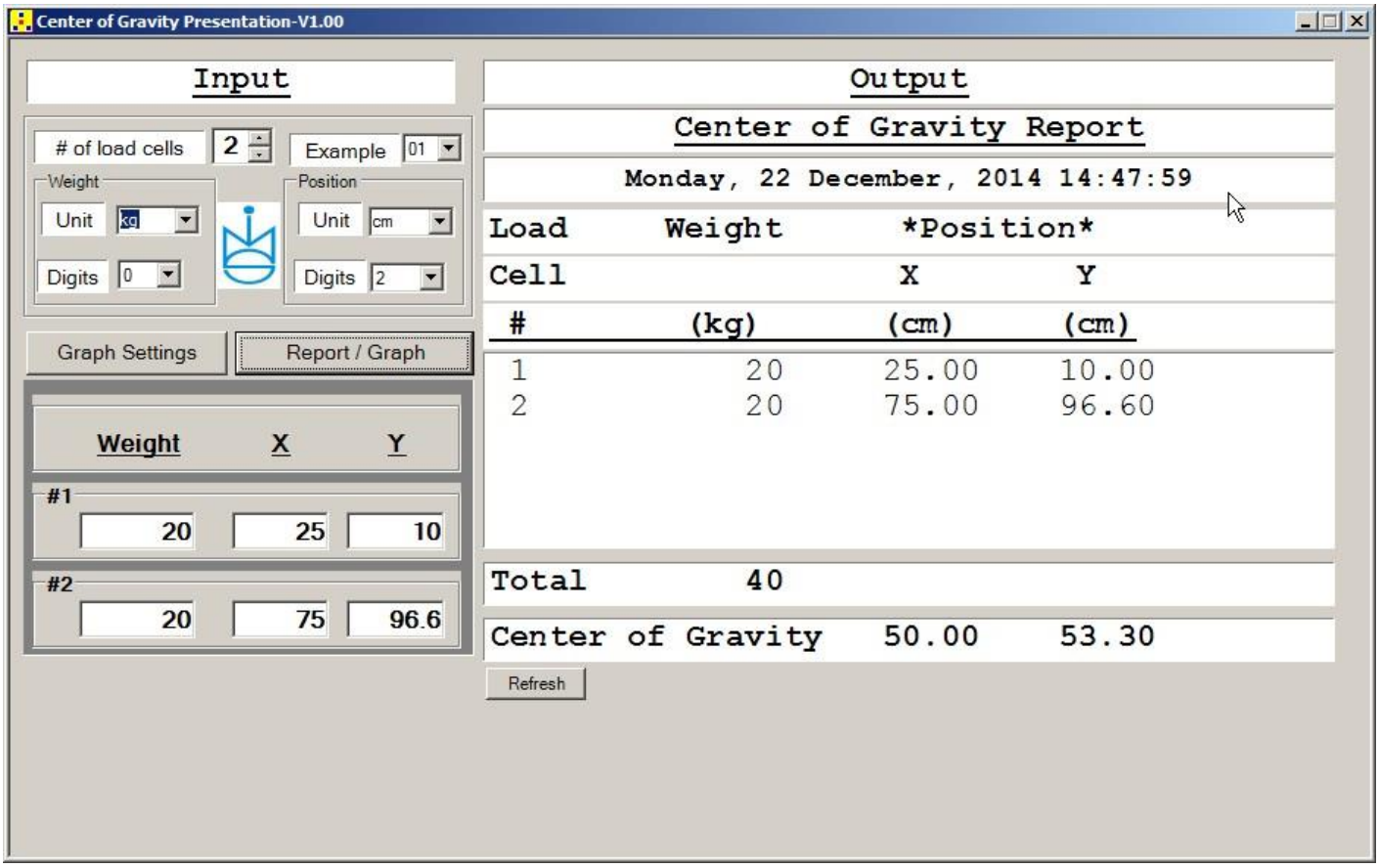
Report & Graph

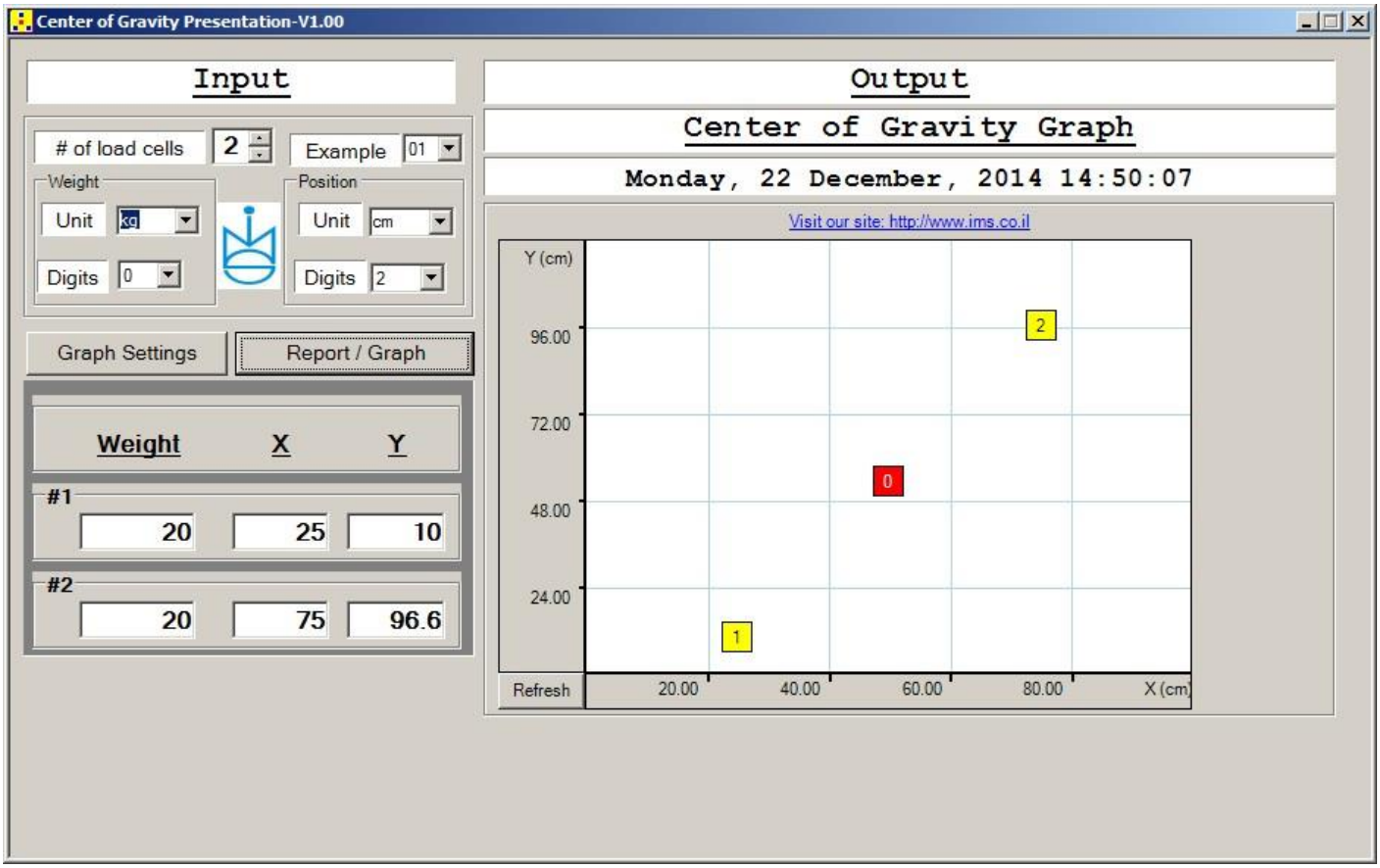
(**Red** part is internal, not part of the report)

MXt = MX1 + MX2 =
500 + 1500 = 2000

MYt = MY1 + MY2 =
200 + 1932 = 2132

Xcg = MXt / 40 = 2000 / 40 = 50.00
Ycg = MYt / 40 = 2132 / 40 = 53.30


Center of Gravity Presentation-V1.00
Input
# of load cells
2
Example
01
Weight
Unit
kg
Digits
0
Position
Unit
cm
Digits
2
Graph Settings
Report / Graph
Weight
X
Y
#1
20
25
10
#2
20
75
96.6
Output
Center of Gravity Report
Monday, 22 December, 2014 14:47:59
Load Cell #
Weight (kg)
Position X (cm)
Y (cm)
1 20 25.00 10.00
2 20 75.00 96.60
Total 40
Center of Gravity 50.00 53.30
Refresh


Center of Gravity Presentation-V1.00
Input
# of load cells
2
Example
01
Weight
Unit
kg
Digits
0
Position
Unit
cm
Digits
2
Graph Settings
Report / Graph
Weight
X
Y
#1
20
25
10
#2
20
75
96.6
Output
Center of Gravity Graph
Monday, 22 December, 2014 14:50:07
Visit our site: http://www.ims.co.il
Y (cm)
96.00
72.00
48.00
24.00
1
2
0
Refresh
20.00
40.00
60.00
80.00
X (cm)

Example #2

This example is the same as example #1, except that the CoG is **not** in line's center.

Given

1. Weight units: kg
2. Length units: cm
3. Position report's format: # of digits after the decimal point for the **CoG X/Y position**: 2
4. Weight report's format: # of digits after the decimal point for the **CoG weight**: 0
5. n: 2
6.

```
W1 = 19,    X1 = 25,    Y1 = 10.
W2 = 21,    X2 = 75,    Y2 = 96.6.
```

Report & Graph

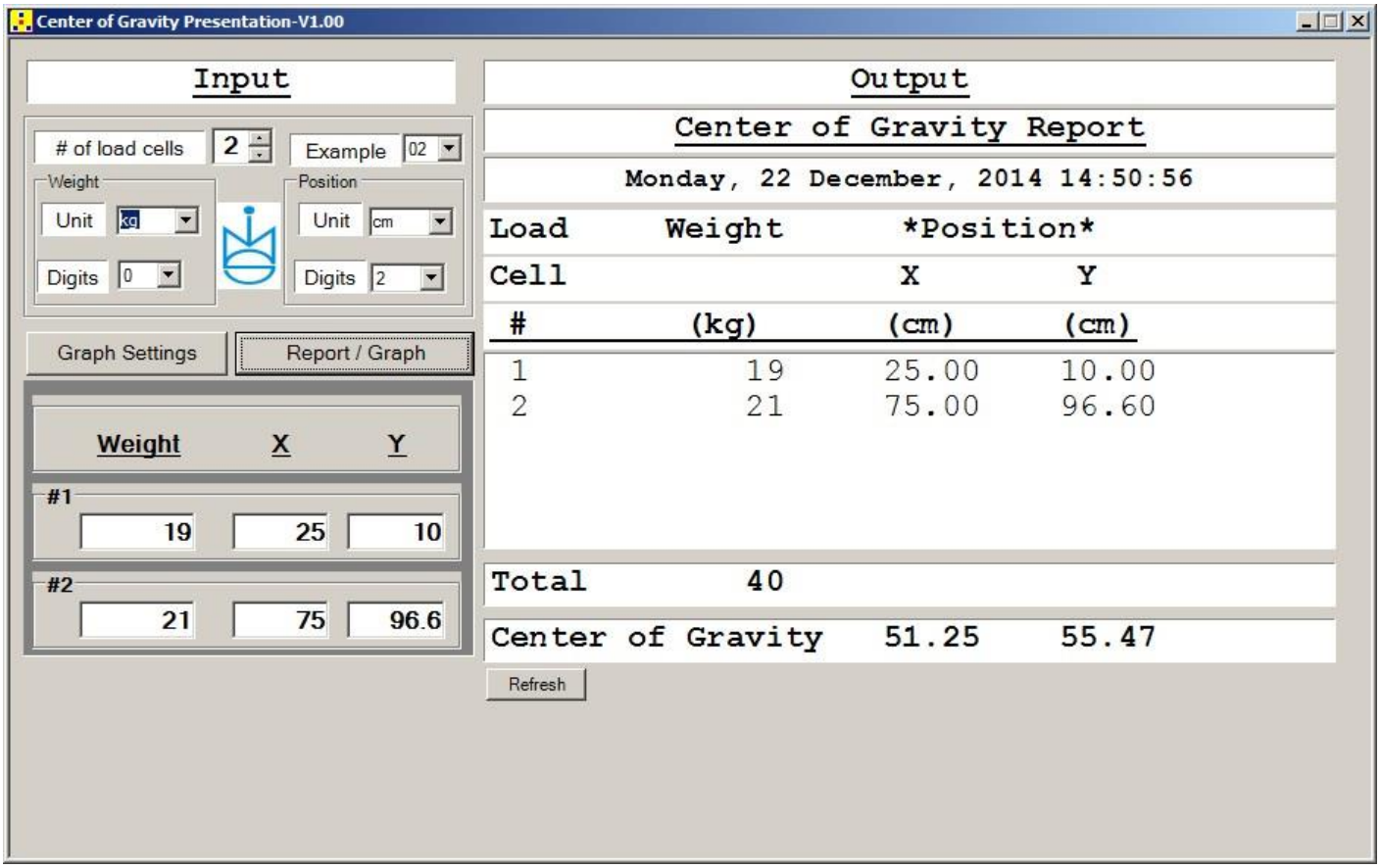
(**Red** part is internal, not part of the report)

```
MXt = MX1 + MX2    =
      475 + 1575   = 2050

MYt = MY1 + MY2    =
      190 + 2028.6 = 2218.6
```

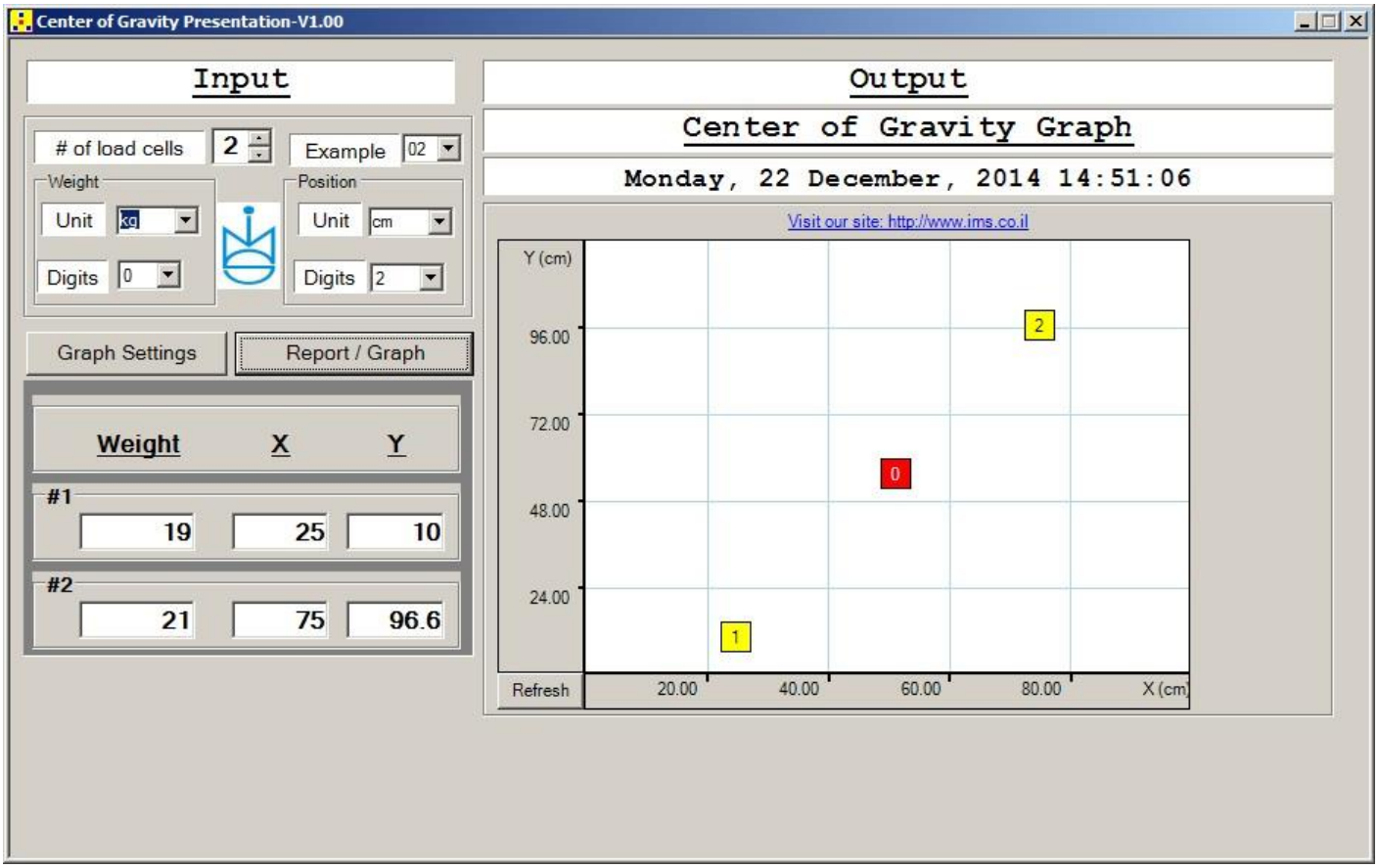
Xcg = MXt / 40 = 2050 / 40 = 51.25

Ycg = MYt / 40 = 2218.6 / 40 = 55.465



(Recall that in example #1 the CoG position was:

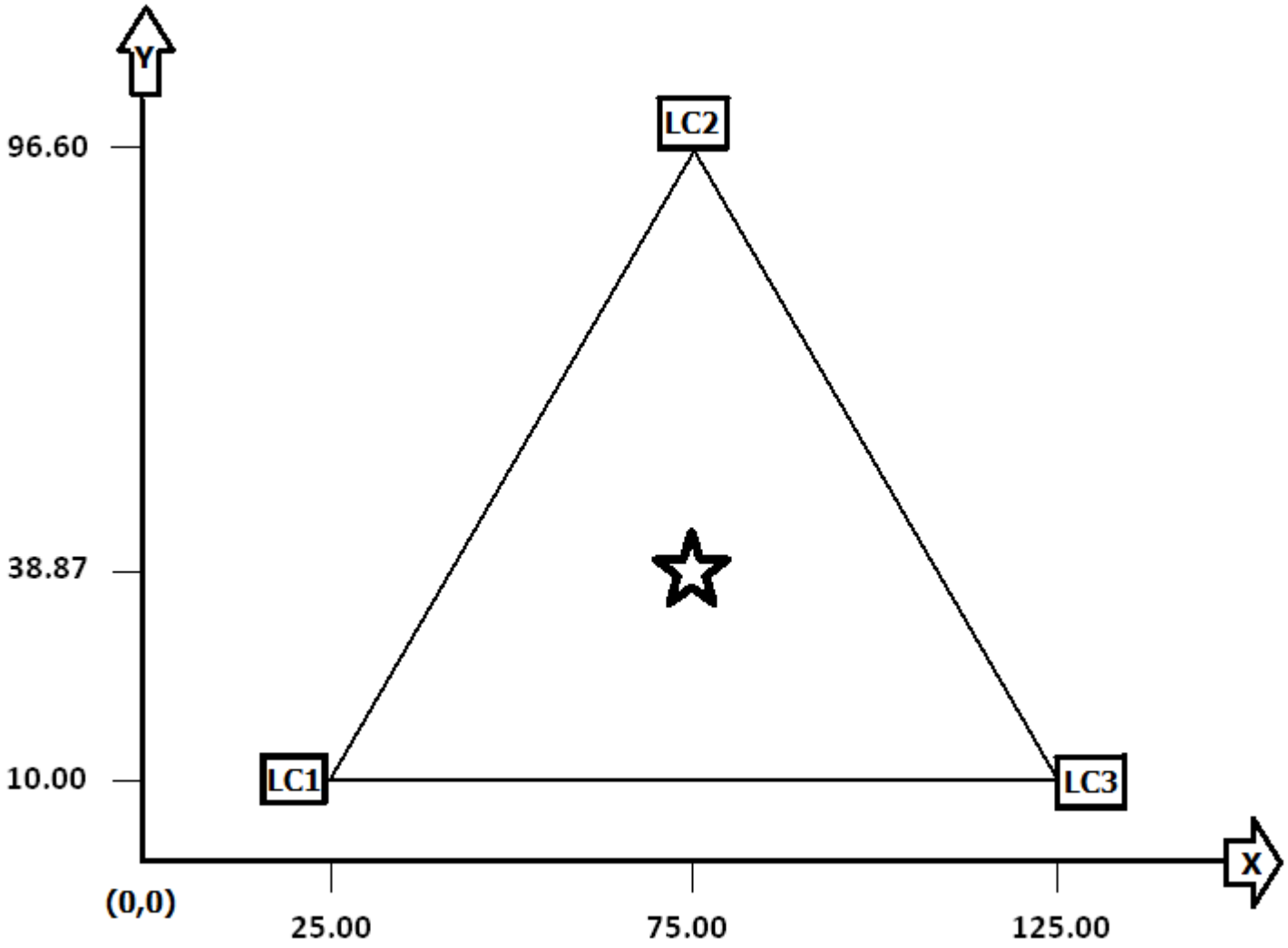
X = 50.00 cm, Y = 53.30 cm.)



Example #3

This example shows a **3 load cells system**.
The load cells are positioned at the 3 corners of an equilateral triangle.
Each side of the triangle = 100 cm.
In this example object's CoG is in triangle's geometrical center.
(According to **Ceva's Theorem** the Y coordinate of the CoG is 1/3 of triangle's height.)

The illustration below shows the system. The CoG is marked by a star.



Given

1. Weight units: kg
2. Length units: cm
3. Position report's format: # of digits after the decimal point for the **CoG X/Y position**: 2
4. Weight report's format: # of digits after the decimal point for the **CoG weight**: 0
5. n: 3
6.

```
W1 = 20,     X1 =  25,     Y1 = 10.
W2 = 20,     X2 =  75,     Y2 = 96.6.
W3 = 20,     X3 = 125,     Y3 = 10.
```

Report & Graph

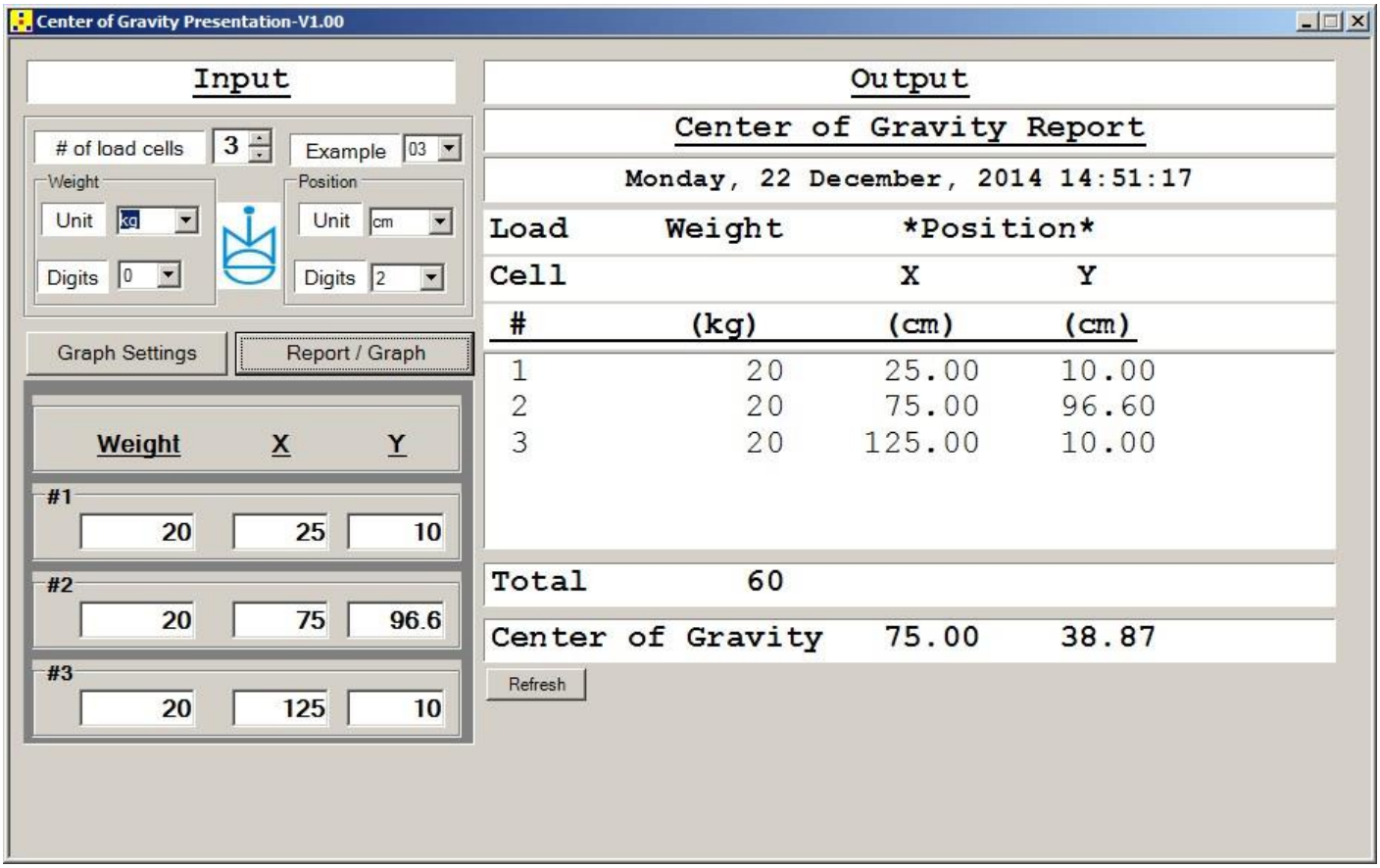
(**Red** part is internal, not part of the report)

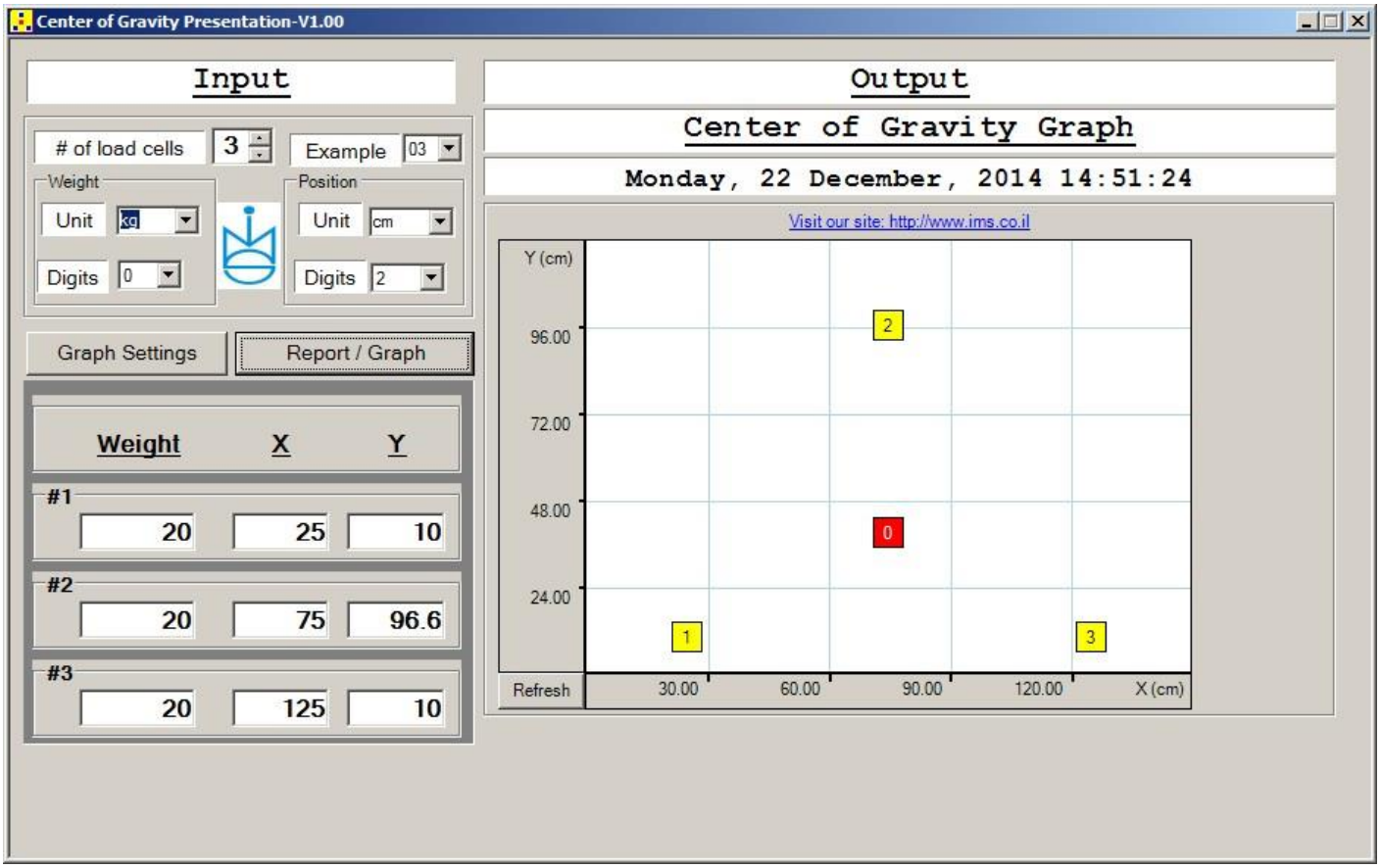
```
MXt = MX1   +  MX2   +  MX3   =
      500   +  1500  +  2500  = 4500

MYt = MY1   +  MY2   +  MY3   =
      200   +  1932  +  200   = 2332
```

Xcg = MXt / 60 = 4500 / 60 = 75.00

Ycg = MYt / 60 = 2332 / 60 = 38.87


Center of Gravity Presentation-V1.00
Input
# of load cells
3
Example
03
Weight
Unit
kg
Digits
0
Position
Unit
cm
Digits
2
Graph Settings
Report / Graph
Weight
X
Y
#1
20
25
10
#2
20
75
96.6
#3
20
125
10
Output
Center of Gravity Report
Monday, 22 December, 2014 14:51:17
Load Cell #
Weight (kg)
Position
X (cm)
Y (cm)
1 20 25.00 10.00
2 20 75.00 96.60
3 20 125.00 10.00
Total 60
Center of Gravity 75.00 38.87
Refresh


Center of Gravity Presentation-V1.00
Input
# of load cells
3
Example
03
Weight
Unit
kg
Digits
0
Position
Unit
cm
Digits
2
Graph Settings
Report / Graph
Weight
X
Y
#1
20
25
10
#2
20
75
96.6
#3
20
125
10
Output
Center of Gravity Graph
Monday, 22 December, 2014 14:51:24
Visit our site: http://www.ims.co.il
Y (cm)
96.00
72.00
48.00
24.00
2
0
1
3
Refresh
30.00
60.00
90.00
120.00
X (cm)

Example #4

This example is the same as example #3, except that the CoG is **not** in triangle's geometrical center.

Given

1. Weight units: kg
2. Length units: cm
3. Position report's format: # of digits after the decimal point for the **CoG X/Y position**: 2
4. Weight report's format: # of digits after the decimal point for the **CoG weight**: 0
5. n: 3
6.

```
W1 = 19,     X1 =  25,     Y1 = 10.
W2 = 21,     X2 =  75,     Y2 = 96.6.
W3 = 20,     X3 = 125,     Y3 = 10.
```

Report & Graph

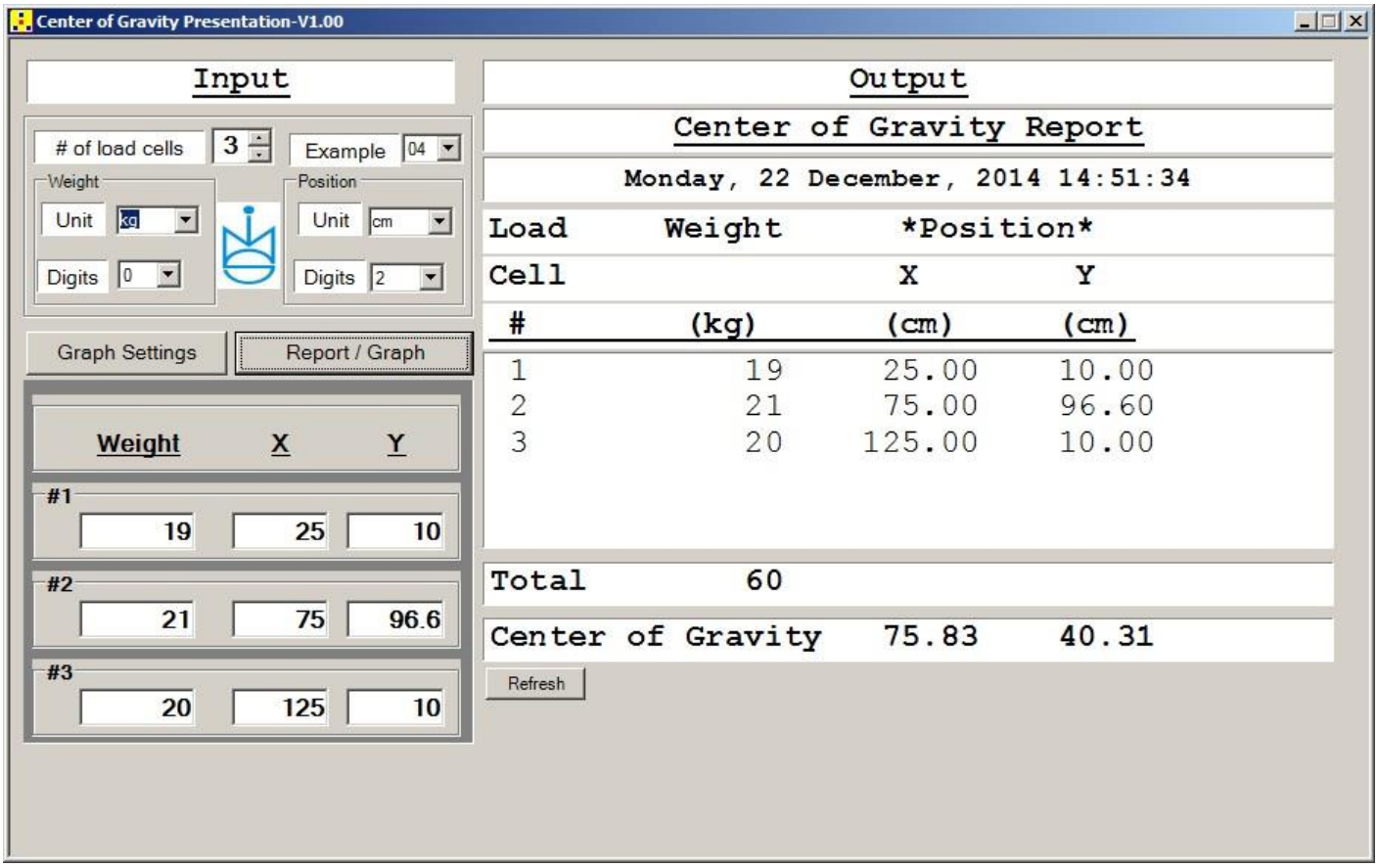
(**Red** part is internal, not part of the report)

```
MXt = MX1   +   MX2   +   MX3 =
      475   +  1575   +  2500 = 4550

MYt = MY1   +   MY2   +   MY3 =
      190   +  2028.6 +   200 = 2418.6
```

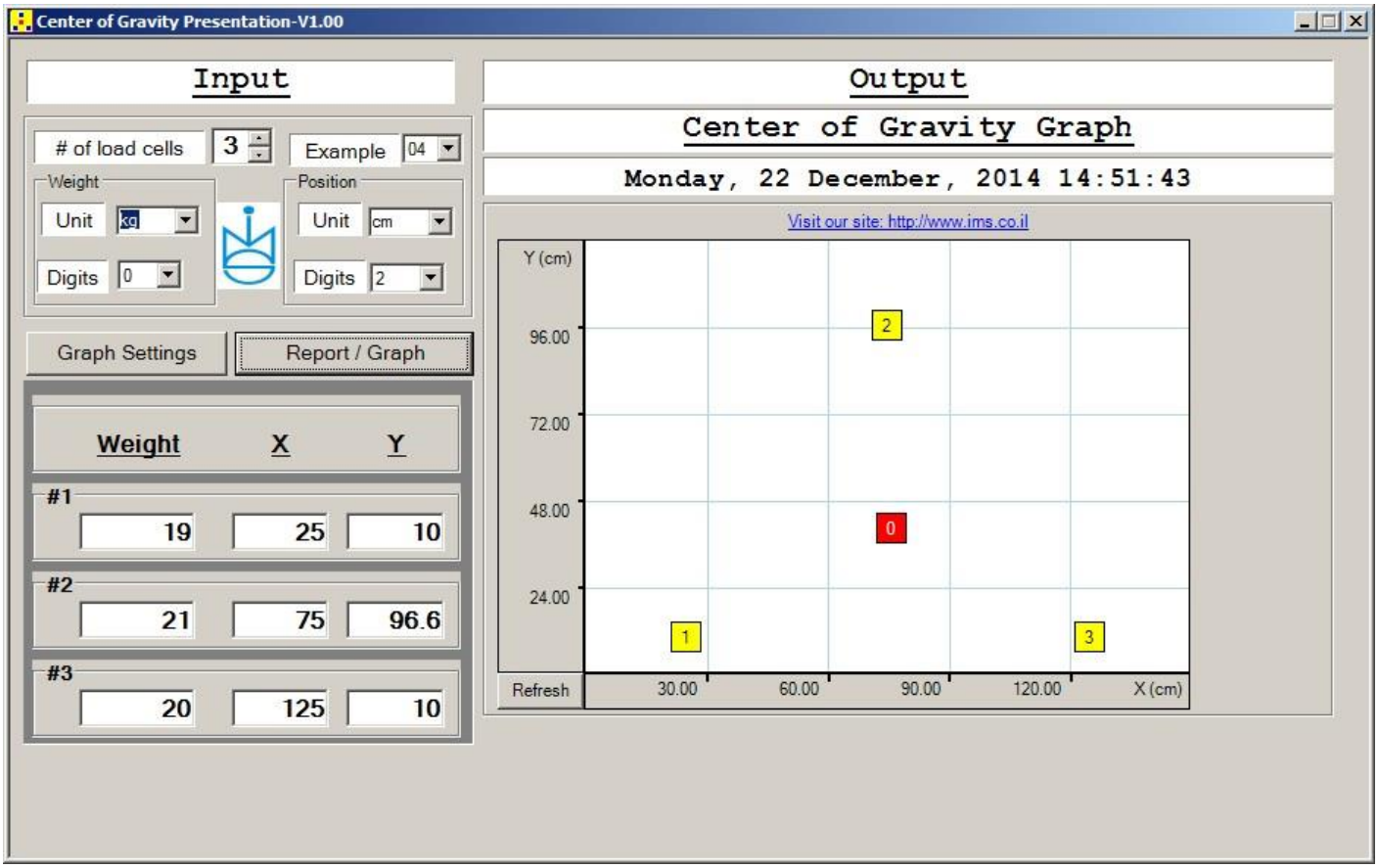
Xcg = MXt / 60 = 4550 / 60 = 75.83

Ycg = MYt / 60 = 2418.6 / 60 = 40.31



(Recall that in example #3 the CoG position was:

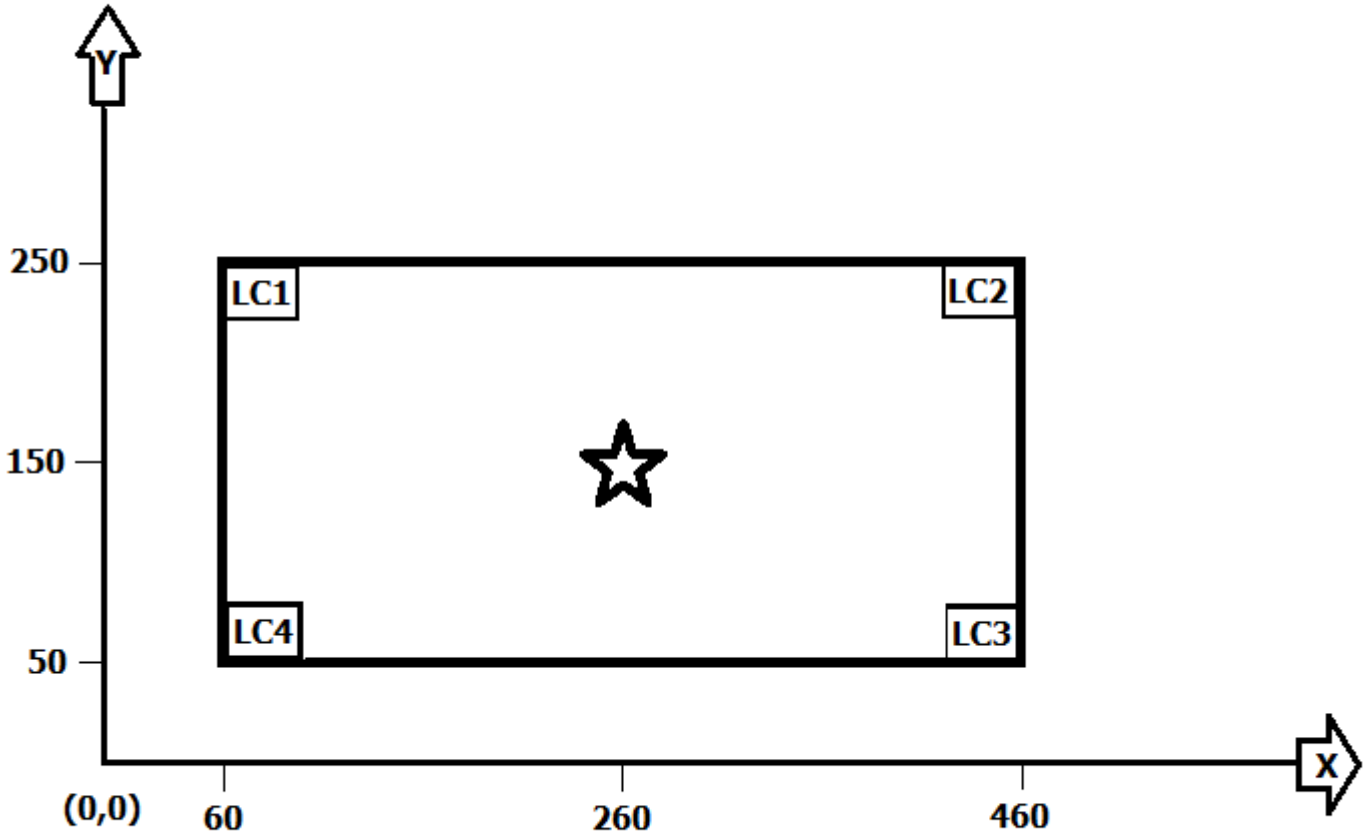
X = 75.00 cm, Y = 38.87 cm.)



Example #5

This example shows a **4 load cells system**.
The load cells are positioned at the 4 corners of a rectangle.
Rectangle's dimensions are 400 * 200 cm.
In this example object's CoG is in rectangle's geometrical center.

The illustration below shows the system. The CoG is marked by a star.



Given

1. Weight units: kg
2. Length units: cm
3. Position report's format: # of digits after the decimal point for the **CoG X/Y position**: 2
4. Weight report's format: # of digits after the decimal point for the **CoG weight**: 0
5. n: 4
6.

```
W1 = 25,    X1 =  60,    Y1 = 250.
W2 = 25,    X2 = 460,    Y2 = 250.
W3 = 25,    X3 = 460,    Y3 =  50.
W4 = 25,    X4 =  60,    Y4 =  50.
```

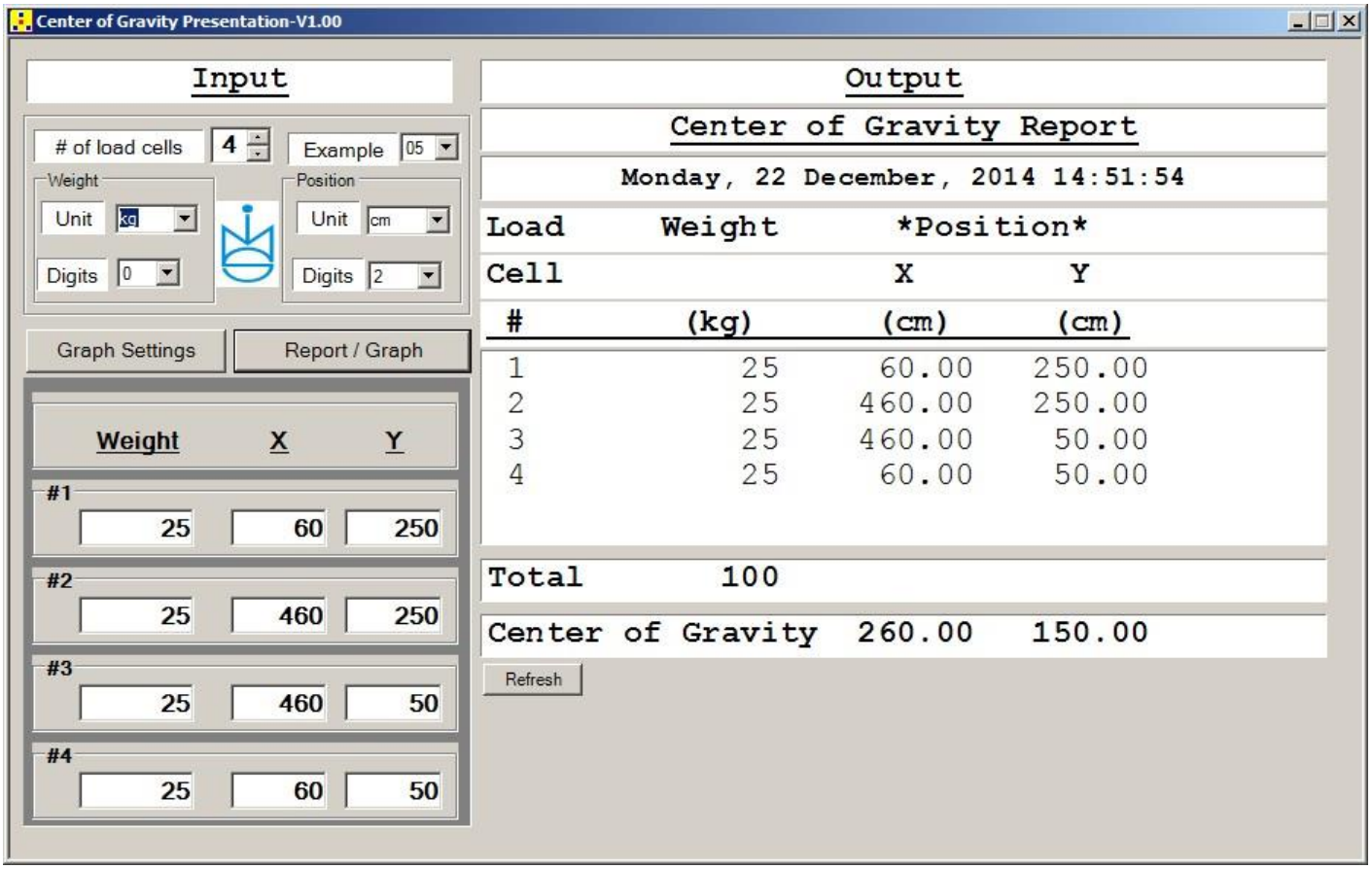
Report & Graph

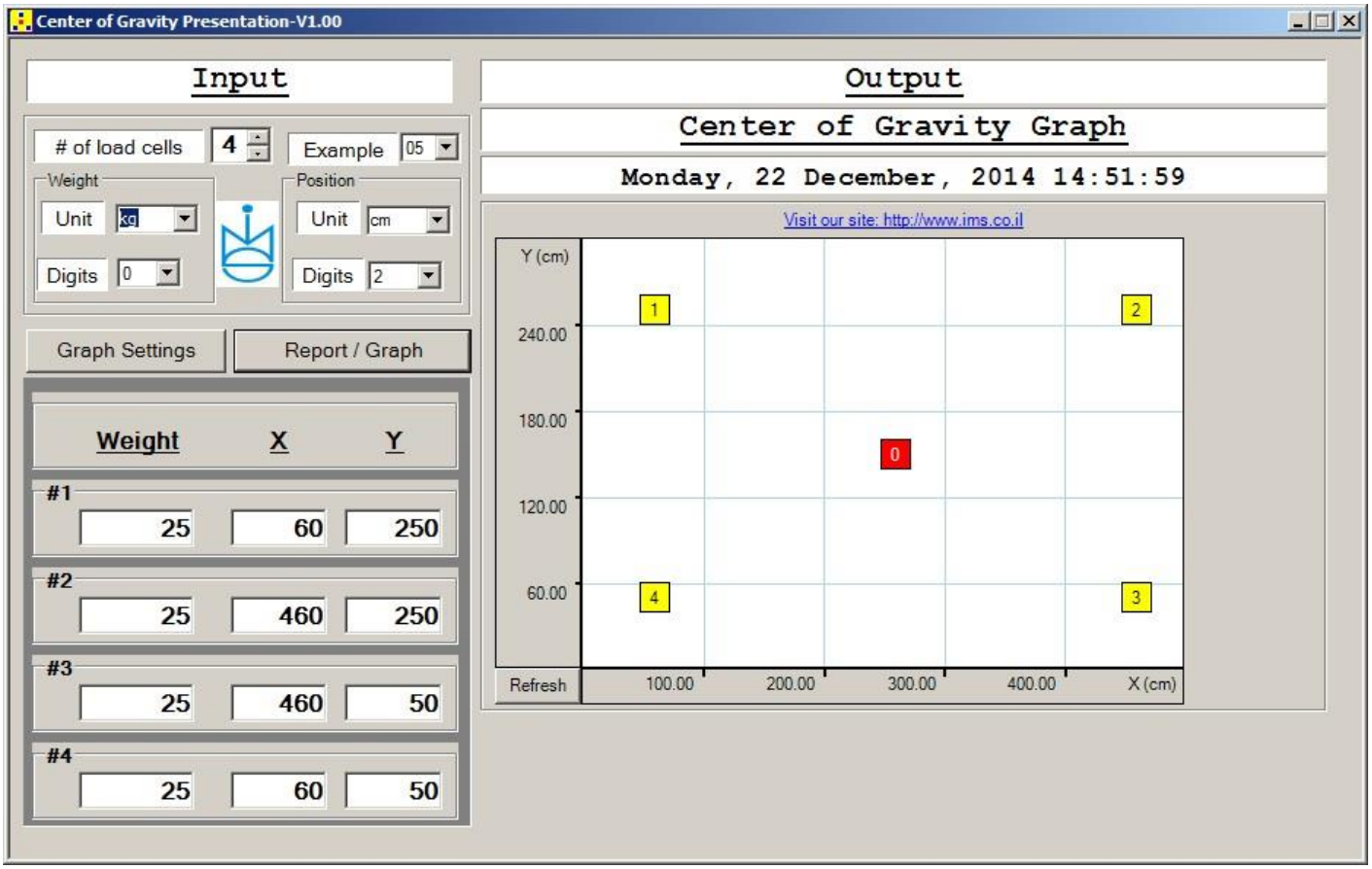
(**Red** part is internal, not part of the report)

MXt = MX1 + MX2 + MX3 + MX4 =
1500 + 11500 + 11500 + 1500 = 26000

MYt = MY1 + MY2 + MY3 + MY4 =
6250 + 6250 + 1250 + 1250 = 15000

Xcg = MXt / 100 = 26000 / 100 = 260.00
Ycg = MYt / 100 = 15000 / 100 = 150.00


Center of Gravity Presentation-V1.00
Input
# of load cells
4
Example
05
Weight
Unit
kg
Digits
0
Position
Unit
cm
Digits
2
Graph Settings
Report / Graph
Weight
X
Y
#1
25
60
250
#2
25
460
250
#3
25
460
50
#4
25
60
50
Output
Center of Gravity Report
Monday, 22 December, 2014 14:51:54
Load Cell #
Weight (kg)
Position
X (cm)
Y (cm)
1 25 60.00 250.00
2 25 460.00 250.00
3 25 460.00 50.00
4 25 60.00 50.00
Total 100
Center of Gravity 260.00 150.00
Refresh


Center of Gravity Presentation-V1.00
Input
# of load cells
4
Example
05
Weight
Unit
kg
Digits
0
Position
Unit
cm
Digits
2
Graph Settings
Report / Graph
Weight
X
Y
#1
25
60
250
#2
25
460
250
#3
25
460
50
#4
25
60
50
Output
Center of Gravity Graph
Monday, 22 December, 2014 14:51:59
Visit our site: http://www.ims.co.il
Y (cm)
240.00
180.00
120.00
60.00
1
2
0
4
3
Refresh
100.00
200.00
300.00
400.00
X (cm)

Example #6

This example is the same as example #5, except that the CoG is **not** in rectangle's geometrical center.

Given

1. Weight units: kg
2. Length units: cm
3. Position report's format: # of digits after the decimal point for the **CoG X/Y position**: 2
4. Weight report's format: # of digits after the decimal point for the **CoG weight**: 0
5. n: 4
6.

```
W1 = 22,    X1 =  60,    Y1 = 250.
W2 = 24,    X2 = 460,    Y2 = 250.
W3 = 25,    X3 = 460,    Y3 =  50.
W4 = 29,    X4 =  60,    Y4 =  50.
```

Report & Graph

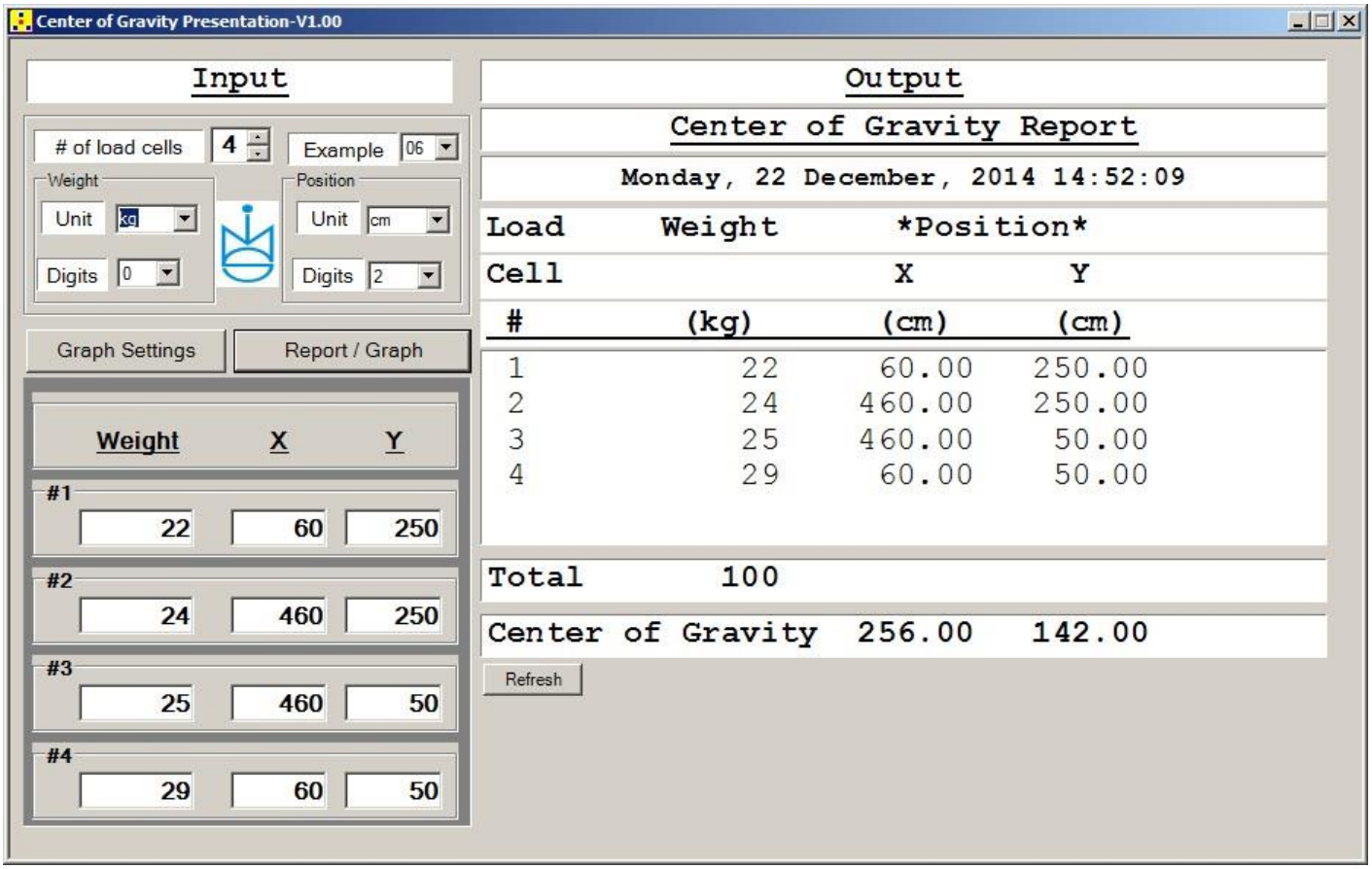
(**Red** part is internal, not part of the report)

```
MXt = MX1  +  MX2  +  MX3  +  MX4 =
      1320 + 11040 + 11500 + 1740 = 25600

MYt = MY1  +  MY2  +  MY3  +  MY4 =
      5500 +  6000 +  1250 + 1450 = 14200
```

Xcg = MXt / 100 = 25600 / 100 = 256.00

Ycg = MYt / 100 = 14200 / 100 = 142.00



(Recall that in example #5 the CoG position was:

X = 260.00 cm, Y = 150.00 cm.)