

# ***Optidef***

A Latex library for optimization problems

Version - 1.2

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# 1 Introduction and features

This small library provides a standard set of environments for writing minimization problems. The most important features are:

1. It automatically aligns the problems in the most convenient way allowing different output formats:

- (a) Alignment at the beginning of the words *minimize/argmin* and *subject to*:

$$\begin{array}{ll} \underset{w}{\text{minimize}} & f(w) + R(w + 6x) \\ \text{subject to} & g(w) = 0 \end{array}$$

- (b) Double format for the location of the constraints: either to the right of *subject to* aligned with the objective function or below *subject to*.
- (c) Optional alignment at the =, >, < signs of the constraints.

$$\begin{array}{ll} \underset{w}{\text{minimize}} & f(w) + R(w + 6x) \\ \text{subject to} & g(w) + h(w) = 0, \\ & l(w) = 5w. \end{array}$$

- (d) Optionally, the user can add a third alignment point on the constraints to set some constraint features. A clear example could be the constraints names:

$$\begin{array}{ll} \underset{w}{\text{minimize}} & f(w) + R(w + 6x) \\ \text{subject to} & g(w) + h(w) = 0, \quad (\text{Topological Constraint}), \\ & l(w) = 5w, \quad (\text{Boundary Constraint}) \end{array}$$

or the index of the constraints:

$$\begin{array}{ll} \underset{w, u}{\text{minimize}} & f(w) + R(w + 6x) \\ \text{subject to} & g(w_k) + h(w_k) = 0, \quad k = 0, \dots, N - 1, \\ & l(w_k) = 5u, \quad k = 0, \dots, N - 1 \end{array}$$

2. It provides an easy interface to define optimization problem for three different reference situations:

- (a) Where no equation is referenced/numbered.
- (b) Where the problem is referenced with a single number.
- (c) Where each equation has an individual reference.

3. It also allows a definition of any optimization problem without a limitless number of constraints.

## 2 Environment types

There are three basic environments depending on the type of referencing that should be used.

1. The **mini** environment for defining problems with a single reference label:

$$\begin{aligned} & \underset{w}{\text{minimize}} && f(w) + R(w + 6x) \\ & \text{subject to} && g(w) = 0 \end{aligned} \tag{1}$$

2. The **mini\*** environment if the problem does not have to be referenced:

$$\begin{aligned} & \underset{w}{\text{minimize}} && f(w) + R(w + 6x) \\ & \text{subject to} && g(w) = 0 \end{aligned}$$

3. The **mini!** environment if each equation should be referenced:

$$\underset{w}{\text{minimize}} \quad f(w) + R(w + 6x) \tag{2a}$$

$$\text{subject to} \quad g(w) = 0 \tag{2b}$$

## 3 Output formats

There are four basic output formats.

1. **Standard format:** by default the constraints are aligned with the objective function, to the right of *subject to* and with a second alignment point at the =, ≤, ≥:

$$\begin{aligned} & \underset{w}{\text{minimize}} && f(w) + R(w + 6x) \\ & \text{subject to} && g(w) + h(w) = 0, \\ & && t(w) = 0. \end{aligned} \tag{3}$$

2. **Alternative 1:** a possible variation is to locate the constraints below *subject to*:

$$\begin{aligned} & \underset{w}{\text{minimize}} && f(w) + R(w + 6x) \\ & \text{subject to} && g(w) + h(w) = 0, \\ & && t(w) = 0. \end{aligned} \tag{4}$$

3. **Alternative 2:** a second variation is to completely remove the second alignment point:

$$\begin{aligned} & \underset{w}{\text{minimize}} && f(w) + R(w + 6x) \\ & \text{subject to} && g(w) + h(w) = 0, \\ & && t(w) = 0. \end{aligned} \tag{5}$$

4. **Alternative 3:** a third variation would be the combination of both of them:

$$\begin{aligned} & \underset{w}{\text{minimize}} && f(w) + R(w + 6x) \\ & \text{subject to} && g(w) + h(w) = 0, \\ & && t(w) = 0. \end{aligned} \tag{6}$$

## 4 Environment Syntaxes

The three environments use the same syntax with the same number of parameters. In particular, considering that *Const* stands for constraint, *LHS* stands for Left-hand-side and *RHS* for Right-hand-side, the basic structure to define a general optimization problem is:

```
\begin{mini#}[Format]
  {Optimization variable}
  {Objective function \label{Objective function referece}}
  {\label{Global referece of Optimization Problem}}
  {Result of the optimization problem or any expression on
the left of the minimize word}

  \addConstraint{LHS Const 1}{RHS Const 1 \label{Reference
Const 1}}{Extra Const 1 Info}
  \addConstraint{LHS Const 2}{RHS Const 2 \label{Reference
Constraint 2}}{Extra Const 2 Info}
  .
  .
  \addConstraint{LHS N}{RHS Const N \label{Reference
Const N}}{Extra Const N Info}
\end{mini#}
```

where  $\# \in \{*,!, \}$ .

### 4.1 Parameters definition

The number of parameters that the environment uses is 6:

1. **Optimization variable**, e.g.  $w \in \mathbb{R}^N$ .
2. **Objective function**, e.g.  $\|w\|_2$ .
3. **\label{Global referece of Optimization Problem}**: it defines the main and general reference for the optimization problem. It is used for the `mini` and `mini!` enviroments. In the `mini*` environment leave it blank, i.e. `{}`.
4. **Result of the optimization problem**: optionally a term expressing the result of the optimization problem, e.g.  $J(w^*) =$ .

5. **Format:** optional parameter to change the format of the constraints. By default the constraints are located at the right of *subject to* and aligned on the  $=, \leq, \geq$  signs. However, as represented in Section 3), the following variations are possible:
  - (a) If Format=1: same alignment as the default format but the constraints appear right below *subject to*. Check Alternative 1 in Section 3).
  - (b) If Format=2: constraints are located on the right of *subject to* but left aligned. Check Alternative 2 in Section 3).
  - (c) If Format=3: constraints are located below *subject to* but left aligned. Check Alternative 3 in Section 3).

Notice that only the first two mandatory parameters (variable and objective) will be really necessary in every definition, nevertheless and for the sake of having homogeneous definitions, we opted for requiring the 4 parameters in every definition and expecting empty parameters definitions, i.e. {}, when they are not needed.

After the definition of this parameters, the environment accepts the definition of an infinite number of constraints. For this definitions the command:

```
\addConstraint{LHS Constraint k}
{RHS Constraint k \label{Reference Constraint k}}
{Extra Infor Constraint k}
```

has to be used, where:

1. **LHS Constraint:** the left-hand side of the any constraint, e.g.  $3w^\top w$ .
2. **RHS Constraint:** the right-hand side of the first constraints including the equal, less and greater signs, e.g.  $\leq \|w\|_\infty$ , as well as the constraint label. **Keep in mind that this parameter is optional and if not included or leave it blank all the constraints will be aligned to the left (See alternative format 2 and 3 in Section 3).**
3. **Extra Info:** optional parameter to add extra info such as constraints set definition or constraint name. Look Example 8 or the fourth described feature in Section 1.

### Constraints referencing

Notice that the label for the constraints is always included in the right hand side expression and it only makes sense for the case of using the `mini!` enviroment. The label of the objective function can also be included in a similar way.

### Example 1 - mini environment

The code:

```
\begin{mini}  
  {w}{f(w)+ R(w+6x)}  
  {\label{eq:Example1}}{}  
  
  \addConstraint{g(w)}{=0}  
  \addConstraint{n(w)}{= 6}  
  \addConstraint{L(w)+r(x)}{=Kw+p}  
  \addConstraint{h(x)}{=0.}  
\end{mini}
```

outputs:

$$\begin{aligned} & \underset{w}{\text{minimize}} && f(w) + R(w + 6x) \\ & \text{subject to} && g(w) = 0, \\ & && n(w) = 6, \\ & && L(w) + r(x) = Kw + p, \\ & && h(x) = 0. \end{aligned} \tag{7}$$

### Example 2 - mini\* environment

On the other hand:

```
\begin{mini*}  
  {w}{f(w)+ R(w+6x)}  
  {}{}  
  
  \addConstraint{g(w)}{=0}  
  \addConstraint{n(w)}{= 6,}  
  \addConstraint{L(w)+r(x)}{=Kw+p}  
  \addConstraint{h(x)}{=0.}  
\end{mini*}
```

it is almost the same but removing the reference:

$$\begin{aligned} & \underset{w}{\text{minimize}} && f(w) + R(w + 6x) \\ & \text{subject to} && g(w) = 0, \\ & && n(w) = 6, \\ & && L(w) + r(x) = Kw + p, \\ & && h(x) = 0. \end{aligned}$$

### Example 3 - mini! environment

Finally, the multireferencing environment outputs:

```
\begin{mini!}
  {w}{f(w)+ R(w+6x) \label{eq:ObjectiveExample1}}
  {\label{eq:Example1}}{}

  \addConstraint{g(w)}{=0 \label{eq:C1Example3}}
  \addConstraint{n(w)}{= 6 \label{eq:C2Example1}}
  \addConstraint{L(w)+r(x)}{=Kw+p \label{eq:C3Example1}}
  \addConstraint{h(x)}{=0. \label{eq:C4Example1}}
\end{mini!}
```

$$\underset{w}{\text{minimize}} \quad f(w) + R(w + 6x) \quad (8a)$$

$$\text{subject to} \quad g(w) = 0, \quad (8b)$$

$$n(w) = 6, \quad (8c)$$

$$L(w) + r(x) = Kw + p, \quad (8d)$$

$$h(x) = 0. \quad (8e)$$

### Example 4 - mini + problem result

Adding the problem result:

```
\begin{mini}
{w}{f(w)+ R(w+6x)}
{\label{eq:Example1}}
{J(w^*)=}

\addConstraint{g(w)}{=0}
\addConstraint{n(w)}{= 6}
\addConstraint{L(w)+r(x)}{=Kw+p}
\addConstraint{h(x)}{=0.}
\end{mini}
```

outputs:

$$\begin{aligned} J(w^*) = \quad & \underset{w}{\text{minimize}} \quad f(w) + R(w + 6x) \\ & \text{subject to} \quad g(w) = 0, \\ & \quad n(w) = 6, \\ & \quad L(w) + r(x) = Kw + p, \\ & \quad h(x) = 0. \end{aligned} \quad (9)$$

### Example 5 - second format

If including a 1 as optional parameter, the first constraint will appear aligned to the left right below *subject to*.

```
\begin{mini}[1]
{w}{f(w)+ R(w+6x)}
{\label{eq:Example1}}
{}

\addConstraint{g(w)}{=0}
\addConstraint{n(w)}{= 6}
\addConstraint{L(w)+r(x)}{=Kw+p}
\addConstraint{h(x)}{=0.}
\end{mini}
```

outputs:

$$\begin{array}{ll} \underset{w}{\text{minimize}} & f(w) + R(w + 6x) \\ \text{subject to} & g(w) = 0, \\ & n(w) = 6, \\ & L(w) + r(x) = Kw + p, \\ & h(x) = 0. \end{array} \tag{10}$$

### Example 6 - third format

If including a 2 as optional parameter, the constraint will appear to the right of *subject to* but a single alignment point.

```
\begin{mini}[2]
{w}{f(w)+ R(w+6x)}
{\label{eq:Example1}}
{}

\addConstraint{g(w)}{=0}
\addConstraint{n(w)}{= 6}
\addConstraint{L(w)+r(x)}{=Kw+p}
\addConstraint{h(x)}{=0.}
\end{mini}
```

outputs:



$$\begin{aligned}
& \underset{w}{\text{minimize}} && f(w) + R(w + 6x) \\
& \text{subject to} && g(w) = 0, \\
& && n(w) = 6, \\
& && L(w) + r(x) = Kw + p, \\
& && h(x) = 0.
\end{aligned} \tag{11}$$

#### Example 7 - fourth format

If including a 3 as optional parameter, the first constraint will appear aligned to the left right below *subject to* and with a single alignment point.

```

\begin{mini}[3]
{w}{f(w)+ R(w+6x)}
{\label{eq:Example1}}
{}

\addConstraint{g(w)}{=0}
\addConstraint{n(w)}{= 6}
\addConstraint{L(w)+r(x)}{=Kw+p}
\addConstraint{h(x)}{=0.}
\end{mini}

```

outputs:

$$\begin{aligned}
& \underset{w}{\text{minimize}} && f(w) + R(w + 6x) \\
& \text{subject to} && g(w) = 0, \\
& && n(w) = 6, \\
& && L(w) + r(x) = Kw + p, \\
& && h(x) = 0.
\end{aligned} \tag{12}$$

#### Example 8 - mini\* + extra constraint alignment

Adding the fourth optional alignment to add constraint names:

```

\begin{mini*}
{w}{f(w)+ R(w+6x)}
{}{}
\addConstraint{g(w)}{=0,}{\quad \text{(Dynamic constraint)}}
\addConstraint{n(w)}{= 6,}{\quad \text{(Boundary constraint)}}
\addConstraint{L(w)+r(x)}{=Kw+p,}{\quad \text{(Random constraint)}}
\addConstraint{h(x)}{=0,}{\quad \text{(Path constraint).}}
\end{mini*}

```

$$\begin{array}{llll}
\underset{w}{\text{minimize}} & f(w) + R(w + 6x) & & \\
\text{subject to} & g(w) = 0, & \text{(Dynamic constraint),} & \\
& n(w) = 6, & \text{(Boundary constraint),} & \\
& L(w) + r(x) = Kw + p, & \text{(Random constraint),} & \\
& h(x) = 0, & \text{(Path constraint).} &
\end{array}$$

**Example 9 - mini environment on the unconstrained case**

```

\begin{mini}
  {w}{f(w)+ R(w+6x)}
  {\label{eq:Ex4}}
{}
\end{mini}

```

outputs:

$$\underset{w}{\text{minimize}} \quad f(w) + R(w + 6x) \tag{13}$$

## 5 The *argmini* environment

Similar to the `mini`, `mini*` and `mini!` environments, the environments `argmini`, `argmini*` and `argmini!` are very similar environments that use the same syntax but the output is slightly different. The following code serves for illustration:

```

\begin{argmini}
  {w}{f(w)+ R(w+6x)}

  {\label{eq:Example1}}{w^*=}

  \addConstraint{g(w)}{=0}
  \addConstraint{n(w)}{= 6}
  \addConstraint{L(w)+r(x)}{=Kw+p}
  \addConstraint{h(x)}{=0.}
\end{argmini}

```

outputs:

$$\begin{aligned}
w^* &= \arg \min_w && f(w) + R(w + 6x) \\
&\text{subject to} && g(w) = 0, \\
&&& n(w) = 6, \\
&&& L(w) + r(x) = Kw + p, \\
&&& h(x) = 0.
\end{aligned} \tag{14}$$

## 6 The *maxi* and *argmaxi* environments

Exactly the same syntax and definition as the previous environments, but now for defining maximization environments. The following code serves for illustration:

```

\begin{maxi}
  {w}{f(w)+ R(w+6x)}
  {g(w)}{=0}

  {\label{eq:Example1}}{}

  \addConstraint{g(w)}{=0}
  \addConstraint{n(w)}{= 6}
  \addConstraint{L(w)+r(x)}{=Kw+p}
  \addConstraint{h(x)}{=0.}
\end{maxi}

```

outputs:

$$\begin{aligned}
&\text{maximize} && f(w) + R(w + 6x) \\
&\text{subject to} && g(w) = 0, \\
&&& n(w) = 6, \\
&&& L(w) + r(x) = Kw + p, \\
&&& h(x) = 0.
\end{aligned} \tag{15}$$

## 7 Problems and limitations

One current limitation is that the size of the optimization variables must be smaller than the word minimize, otherwise, the output is not properly aligned. Example:

$$\begin{aligned} & \underset{x_0, u_0, x_1, \dots, u_{N-1}, x_N}{\text{minimize}} && \sum_{k=0}^{N-1} L(x_k, u_k) + E(x_N) \end{aligned} \quad (16a)$$

$$\text{subject to} \quad x_{k+1} - f(x_k, u_k) = 0, \quad k = 0, \dots, N-1, \quad (16b)$$

$$h(x_k, u_k) \leq 0, \quad k = 0, \dots, N-1, \quad (16c)$$

$$r(x_0, x_N) = 0. \quad (16d)$$

A possible way to avoid this is to stack them with the command:

`\substack{x_0, u_0, x_1, \dots, u_{N-1}, x_N}`

$$\begin{aligned} & \underset{\substack{x_0, u_0, x_1, \dots, \\ u_{N-1}, x_N}}{\text{minimize}} && \sum_{k=0}^{N-1} L(x_k, u_k) + E(x_N) \end{aligned} \quad (17a)$$

$$\text{subject to} \quad x_{k+1} - f(x_k, u_k) = 0, \quad k = 0, \dots, N-1, \quad (17b)$$

$$h(x_k, u_k) \leq 0, \quad k = 0, \dots, N-1, \quad (17c)$$

$$r(x_0, x_N) = 0. \quad (17d)$$

## 8 Code definition

```
% optidef - Version 1.2
%
% Copyright 2016 J. Lago Garcia
%
% This work may be distributed and/or modified under the
% conditions of the LaTeX Project Public License, either
% version 1.3 of this license or (at your option) any
% later version.
% The latest version of this license is in http://www.
% latex-project.org/lppl.txt and version 1.3 or later is
% part of all distributions of LaTeX version 2005/12/01
% or later.
%
% This work has the LPPL maintenance status 'maintained'.
% The Current Maintainer of this work is J. Lago Garcia,
% under the supervision of Prof. Dr. Moritz Diehl and
% Prof. Dr. Sebastien Gross.
%
% E-mail: jesus.lago.garcia@venus.uni-freiburg.de
```

```

%
%This work consists of the file optidef.sty.

\NeedsTeXFormat{LaTeX2e}
\ProvidesPackage{optidef}[2016/06/28 – version=1.2,
    Package for defining optimization problems]

\RequirePackage{environ}
\RequirePackage{mathtools}
\RequirePackage{xifthen}
\RequirePackage{etoolbox}
\RequirePackage{xparse}
\RequirePackage{multirow}

% Toogle to indicate if during the addConstraint command
% the first constraint should be built together with "
% subject to"
\newtoggle{bodyCon}
\toggletrue{bodyCon}

% If the previous constraints has 3 elements, we avoid
% setting \span\span at the beginning of the next
% constraint. If there is no previous third element, \
% span\span must be included for correct alignment
\newtoggle{previousThird}
\togglefalse{previousThird}
\newcommand{\spanit}{}

% Macros for objective definition, constraint definition
% and extra constraint definition
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% % ————— DEFINITION COMMAND OBJECTIVE —————
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
\newcommand{\bodyobj}[4]
{
\ifthenelse{\isempty{#4}}
{
% ${\mathrm{#3}} \quad #2\span\
\span\span\span
&\underset{\displaystyle #1}{\mathrlap{\mathrm{#3}}}\
\phantom{\mathrm{subject\to}}} \quad #2\span\span\span\
\span
}
{
%#4 ~  ${\mathrm{#3}} \quad$$ 
```

```

#2\span\span\span\span
#4 ~ ~ &\underset{\displaystyle #1}{\mathrlap{\mathrm
{\#3}}\phantom{\mathrm{subject~to}}}} \quad #2\span\span
\span\span
}
}

```

```

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% ----- DEFINITION DIFFERENT TYPE OF BODY CONSTRAINTS
% -----
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

```

```

\DeclareDocumentCommand{\bodyconst}{m G{}}
{
  \ifthenelse{\equal{\#2}{}}{
    \&\mathrm{subject~to} \quad \&\#1 \#2
  }{
    \&\mathrm{subject~to} \quad \&\#1 & \#2
  }
}

```

```

% Standard version
\DeclareDocumentCommand{\bodyconstRight}{m G{ } G{}}
{
  \ifthenelse{\equal{\#3}{}}{
    \ifthenelse{\equal{\#2}{}}{
      \&\mathrm{subject~to} \quad \&\#1 \#2
    }{
      \&\mathrm{subject~to} \quad \&\#1 & \#2
    }
  }
  \togglefalse{previousThird}
  {
    \ifthenelse{\equal{\#2}{}}{
      \&\mathrm{subject~to} \quad \&\#1 \#2 & \#3
    }{
      \&\mathrm{subject~to} \quad \&\#1 & \#2 & \#3
    }
  }
  \toggletrue{previousThird}
}

```

```

% Single alignment point
\DeclareDocumentCommand{\bodyconstOneAlign}{m G{ } G{}}
{
  \ifthenelse{\equal{\#3}{}}{
    \&\mathrm{subject~to} \quad \&\#1 \#2 \quad \togglefalse{
      previousThird}
  }
}

```

```

}{
\\ &\mathrm{subject~to} \quad \mathbf{quad} \quad \&\#1 \quad \&\#2 \quad \&\#3
\toggletrue{previousThird}
}
}

% Constraints below subject to and with a single alignment
point
\DeclareDocumentCommand{\bodyconstOneAlignBelow}{m G{} G
{} }
{
\ifthenelse{\equal{\&\#3}{}}{
\\ &\mathrm{subject~to} \quad \mathbf{span}\mathbf{span}\mathbf{span} \quad \\
\&\&\#1 \quad \&\#2 \quad \togglefalse{previousThird}
}{
\\ &\mathrm{subject~to} \quad \mathbf{span}\mathbf{span}\mathbf{span}\mathbf{span} \quad \\
\&\&\#1 \quad \&\#2 \quad \&\#3
\toggletrue{previousThird}
}
}

% Constraints below subject to
\DeclareDocumentCommand{\bodyconstBelow}{m G{} G{} }
{
\ifthenelse{\equal{\&\#3}{}}{
\ifthenelse{\equal{\&\#2}{}}{
\\ &\mathrm{subject~to} \quad \mathbf{span}\mathbf{span}\mathbf{span} \quad \\
\&\&\#1 \quad \&\#2
}{
\\ &\mathrm{subject~to} \quad \mathbf{span}\mathbf{span}\mathbf{span}\mathbf{span} \quad \\
\&\&\#1 \quad \&\#2
}
\togglefalse{previousThird}
}{
\ifthenelse{\equal{\&\#2}{}}{
\\ &\mathrm{subject~to} \quad \mathbf{span}\mathbf{span}\mathbf{span}\mathbf{span} \quad \\
\&\&\#1 \quad \&\#2 \quad \&\#3
}{
\\ &\mathrm{subject~to} \quad \mathbf{span}\mathbf{span}\mathbf{span}\mathbf{span} \quad \\
\&\&\#1 \quad \&\#2 \quad \&\#3
}
\toggletrue{previousThird}
}
}

% Constraints below subject to for the case of having

```

```

    multiple equations
\DeclareDocumentCommand{\bodyconstBelowMult}{m G{} G{}}
{
\ifthenelse{\equal{#3}{}}{
\ifthenelse{\equal{#2}{}}{
\\ &\mathrm{subject~to} \ \span\span\span\span \nonumber \\
&&\#1 \ #2
}{
\\ &\mathrm{subject~to} \ \span\span\span\span \nonumber \\
&&\#1 & \ #2
}
\togglefalse{previousThird}
}{
\ifthenelse{\equal{#2}{}}{
\\ &\mathrm{subject~to} \ \span\span\span\span \nonumber \\
&&\#1 \ #2 &&\#3
}{
\\ &\mathrm{subject~to} \ \span\span\span\span \nonumber \\
&&\#1 & \ #2 &&\#3
}
\toggletrue{previousThird}
}
}

```

*% Constraints below subject to and with a single alignment point for the case of having several equations*

```

\DeclareDocumentCommand{\bodyconstOneAlignBelowMult}{m G
{} G{}}
{
\ifthenelse{\equal{#3}{}}{
\\ &\mathrm{subject~to} \ \span\span\span\span \nonumber \\
&&\#1 \ #2 \togglefalse{previousThird}
}{
\\ &\mathrm{subject~to} \ \span\span\span\span \nonumber \\
&&\#1 \ #2 &&\#3 \toggletrue{previousThird}
}
}

```

```

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% ----- DEFINITION DIFFERENT TYPE OF ADDING
% CONSTRAINTS ----- %
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

```

```

\DeclareDocumentCommand{\addConstraint}{m G{} G{}}{

```



```

\ifthenelse{\equal{#3}{}}{
\ifthenelse{\equal{#2}{}}{
\iftoggle{bodyCon}{
\bodyconst{#1}
\togglefalse{bodyCon}
}{
,\&\quad \&\#1 \#2\span\span
\togglefalse{bodyCon}
}
}{
\iftoggle{bodyCon}{
\bodyconst{#1}{#2}
\togglefalse{bodyCon}
}{
,\&\quad \&\#1 \& \#2\span\span
\togglefalse{bodyCon}
}
}
\togglefalse{previousThird}
}{
\iftoggle{bodyCon}{
\bodyconst{#1}{#2}{#3}
\togglefalse{bodyCon}
}{
\ifthenelse{\equal{#2}{}}{
,\&\quad \&\#1 \#2 \& \#3
}{
,\&\quad \&\#1 \& \#2 \& \#3
}
\togglefalse{bodyCon}
}
\toggletrue{previousThird}
}
}

% Standard version of adding constraints
\DeclareDocumentCommand{\standardAddConstraint}{m G{} G
{} }{
\iftoggle{previousThird}
{\renewcommand{\spanit}{} }
{\renewcommand{\spanit}{\span\span} }
\iftoggle{bodyCon}{
\bodyconstRight{#1}{#2}{#3}
\togglefalse{bodyCon}
}{
\ifthenelse{\equal{#2}{}}{

```

```

\ifthenelse{\equal{#3}{}}{
,\spanit\\&\quad &\#1 \#2
\togglefalse{previousThird}
}{
,\spanit\\&\quad &\#1 \#2 &\#3
\toggletrue{previousThird}
}
}{
\ifthenelse{\equal{#3}{}}{
,\spanit\\&\quad &\#1 &\#2
\togglefalse{previousThird}
}{
,\spanit\\&\quad &\#1 &\#2 &\#3
\toggletrue{previousThird}
}
}
\togglefalse{bodyCon}
}
}

% Adding constraints below subject to
\DeclareDocumentCommand{\BelowAddConstraint}{m G{} G{}}{
\iftoggle{bodyCon}{
\bodyconstBelow{#1}{#2}{#3}
\togglefalse{bodyCon}
}{
\ifthenelse{\equal{#2}{}}{
\ifthenelse{\equal{#3}{}}{
,\spanit\\&&\#1 \#2 \togglefalse{
previousThird}
}{
,\spanit\\&&\#1 \#2 &\#3
\toggletrue{previousThird}
}
}{
\ifthenelse{\equal{#3}{}}{
,\spanit\\ &\#1 &\#2 \togglefalse{previousThird}
}{
,\spanit\\ &\#1 &\#2 &\#3
\toggletrue{previousThird}
}
}
\togglefalse{bodyCon}
}
}

```

```

% Adding constraints for a single alignment point
\DeclareDocumentCommand{\oneAlignAddConstraint}{m G{} G
  {} }{
  \iftoggle{bodyCon}{
    \bodyconstOneAlign{#1}{#2}{#3}
    \togglefalse{bodyCon}
  }{
    \ifthenelse{\equal{#3}{} }{
      ,\spanit\\&\quad \&\#1 \quad #2 \togglefalse{previousThird}
    }{
      ,\spanit\\&\quad \&\#1 \quad #2 \&\& #3
      \toggletrue{previousThird}
    }
    \togglefalse{bodyCon}
  }
}

% Adding constraints for a single alignment point and
% with the constraints below
\DeclareDocumentCommand{\oneAlignBelowAddConstraint}{m G
  {} G{} }{
  \iftoggle{bodyCon}{
    \bodyconstOneAlignBelow{#1}{#2}{#3}
    \togglefalse{bodyCon}
  }{
    \ifthenelse{\equal{#3}{} }{
      ,\spanit\\& \&\#1 \quad #2 \togglefalse{previousThird}
    }{
      ,\spanit\\& \&\#1 \quad #2 \&\& #3
      \toggletrue{previousThird}
    }
    \togglefalse{bodyCon}
  }
}

% Adding constraints below subject to for multiple
% references
\DeclareDocumentCommand{\BelowAddConstraintMult}{m G{} G
  {} }{
  \iftoggle{bodyCon}{
    \bodyconstBelowMult{#1}{#2}{#3}
    \togglefalse{bodyCon}
  }{
    \ifthenelse{\equal{#3}{} }{
      \ifthenelse{\equal{#2}{} }{
        ,\spanit\\&\&\#1 \quad #2

```

```

}{
,\spanit\\&&\#1&\#2
}
\togglefalse{previousThird}
}{
\ifthenelse{\equal{\#2}{}}{
,\spanit\\&&\#1&\#2&&\#3
}{
,\spanit\\&&\#1&\#2&&\#3
\toggletrue{previousThird}
}
\togglefalse{bodyCon}
}
}

```

*% Adding constraints for a single alignment point and  
with the constraints below for multiple references*

```

\DeclareDocumentCommand{\oneAlignBelowAddConstraintMult}{
m G{} G{} }{
\iftoggle{bodyCon}{
\bodyconstOneAlignBelowMult{\#1}{\#2}
\togglefalse{bodyCon}
}{
\ifthenelse{\equal{\#3}{}}{
,\spanit\\&&\#1&\#2\togglefalse{previousThird}
}{
,\spanit\\&&\#1&\#2&&\#3
\toggletrue{previousThird}
}
\togglefalse{bodyCon}
}
}

```

```

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% ----- SELECTING TYPE OF FORMAT ----- %
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
\newcommand{\selectConstraint}[1]{
\ifthenelse{\equal{\#1}{1}}{
\let\addConstraint\BelowAddConstraint
}{
\ifthenelse{\equal{\#1}{2}}{
\let\addConstraint\oneAlignAddConstraint
}{
\ifthenelse{\equal{\#1}{3}}{
\let\addConstraint\oneAlignBelowAddConstraint
}{

```

```

\let\addConstraint\standardAddConstraint}
}
}
}

```

```

% Selecting for multiple references
\newcommand{\selectConstraintMult}[1]{
\ifthenelse{\equal{#1}{1}}{
\let\addConstraint\BelowAddConstraintMult
}{
\ifthenelse{\equal{#1}{2}}{
\let\addConstraint\oneAlignAddConstraint
}{
\ifthenelse{\equal{#1}{3}}{
\let\addConstraint\oneAlignBelowAddConstraintMult
}{
\let\addConstraint\standardAddConstraint}
}
}
}

```

```

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% ----- SETTING DEFAULT FORMAT ----- %
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
\newcommand{\setStandardMini}{
\toggletrue{bodyCon}
\let\addConstraint\standardAddConstraint
}

```

```

\newcommand{\breakObjectiveOneConstraint}[1]{&&&#1\\}

```

*%MINIMIZATION ENVIRONMENTS*

```

\NewEnviron{mini}[5][]{%
\selectConstraint{#1}
\let\addConstraint\standardAddConstraint
\begin{equation}
#4
\begin{alignedat}{5}
\bodyobj{#2}{#3}{minimize}{#5}
\BODY
\end{alignedat}
\end{equation}

```

```

\setStandardMini
}

\NewEnviron{argmini}[5][]{%
\selectConstraint{#1}
\begin{equation}
#4
\begin{alignedat}{5}
\bodyobj{#2}{#3}{arg~min}{#5}
\BODY
\end{alignedat}
\end{equation}
\setStandardMini
}

\NewEnviron{mini*}[5][]{%
\selectConstraint{#1}
\begin{alignat*}{5}
\bodyobj{#2}{#3}{minimize}{#5}
\BODY
\end{alignat*}
\setStandardMini
}

\NewEnviron{argmini*}[5][]{%
\selectConstraint{#1}
\begin{alignat*}{5}
\bodyobj{#2}{#3}{arg~mini}{#5}
\BODY
\end{alignat*}
\setStandardMini
}

\NewEnviron{mini!}[5][]{%
\selectConstraintMult{#1}
\begin{subequations}
#4
\begin{alignat}{5}
\bodyobj{#2}{#3}{minimize}{#5}
\BODY
\end{alignat}
\end{subequations}
\setStandardMini
}

```

```

\NewEnviron{argmini}[5][]{%
\selectConstraintMult{#1}
\begin{subequations}
#4
\begin{alignat}{5}
\bodyobj{#2}{#3}{arg~min}{#5}
\BODY
\end{alignat}
\end{subequations}
\setStandardMini
}

```

*%MAXIMIZATION ENVIRONMENTS*

```

\NewEnviron{maxi}[5][]{%
\selectConstraint{#1}
\begin{equation}
#4
\begin{alignedat}{5}
\bodyobj{#2}{#3}{maximize}{#5}
\BODY
\end{alignedat}
\end{equation}
\setStandardMini
}

```

```

\NewEnviron{argmaxi}[5][]{%
\selectConstraint{#1}
\begin{equation}
#4
\begin{alignedat}{5}
\bodyobj{#2}{#3}{arg~maxi}{#5}
\BODY
\end{alignedat}
\end{equation}
\setStandardMini
}

```

```

\NewEnviron{maxi*}[5][]{%
\selectConstraint{#1}
\begin{alignat*}{5}
\bodyobj{#2}{#3}{maximize}{#5}
\BODY
\end{alignat*}
\setStandardMini
}

```

```

\NewEnviron{argmaxi*}[5][]{%
\selectConstraint{#1}
\begin{alignat*}{5}
\bodyobj{#2}{#3}{arg~maxi}{#5}
\BODY
\end{alignat*}
\setStandardMini
}

```

```

\NewEnviron{maxi!}[5][]{%
\selectConstraintMult{#1}
\begin{subequations}
#4
\begin{alignat}{5}
\bodyobj{#2}{#3}{maximize}{#5}
\BODY
\end{alignat}
\end{subequations}
\setStandardMini
}

```

```

\NewEnviron{argmaxi!}[5][]{%
\selectConstraintMult{#1}
\begin{subequations}
#4
\begin{alignat}{5}
\bodyobj{#2}{#3}{arg~maxi}{#5}
\BODY
\end{alignat}
\end{subequations}
\setStandardMini
}

```