

Optidef

A Latex library for optimization problems

Version - 2.0

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1 Introduction and features

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

1. It references optimization problem using three different policies: no equation is referenced, the problem is referenced with a single label, each equation has an individual reference.
2. It defines two problem size formats: a long format and a short format.
3. It allows four different outputs for the location of the constraints.
4. It allows the definition of a limitless number of constraints.
5. Four different type of problems: *minimize*, *maximize*, *arg min* and *arg max*.

2 Environment Syntax Definition

Considering that `Const.i` stands for constraint i , `LHS.i` stands for the left-hand-side of constraint i , and `RHS.i` for the right-hand-side counterpart, the basic structure to define a general optimization problem with N constraints is:

```
\begin{mini#}|sizeFormat|[constraintFormat]
{optimizationVariable}
{objectiveFunction\label{objective}}
{\label{optimizationProblem}}
{optimizationResult}

\addConstraint{LHS.1}{RHS.1\label{Const1}}{extraConst1}
\addConstraint{LHS.2}{RHS.2\label{Const2}}{extraConst2}
.
.
\addConstraint{LHS.N}{RHS.N\label{ConstN}}{extraConstN}
\end{mini#}
```

2.1 Definition of Problem parameters

- (i) `mini#`: defines the type of environment and reference used. There are four environments: `mini`, `maxi`, `argmini`, and `argmaxi`. There are three types of referencing: `mini`, `mini*` and `mini!`. Consult Section 3 for more details.
- (ii) (Optional) `sizeFormat`: optional parameter to define the size format of the problem. The possible values are:
 - l: for the long format as defined in Section 4.
 - s: for the short format as defined in Section 4.

- (iii) (Optional) `constraintFormat`: optional parameter to change the format of the constraints. The parameter `constraintFormat` can take the following values:
 - 0: for the Standard definition in Section 6.
 - 1: for Alternative 1 in Section 6.
 - 2: for Alternative 2 in Section 6
 - 3: for Alternative 3 in Section 6
- (iv) `optimizationVariable`: variable to be optimized in the problem, e.g. $w \in \mathbb{R}^N$.
- (v) `objectiveFunction\label{objective}`: function to be minimized/maximized as a function of the optimization variable, e.g. $\|w\|_2$. If required, the objective function label should also be included withing this term
- (vi) `\label{optimizationProblem}`: it defines the main and general reference for the optimization problem. It is used for the `mini` and `mini!` enviroments. In the `mini*` environment should be left blank, i.e. `{}`, **not to be ommited**.
- (vii) `optimizationResult`: a term expressing the result of the optimization problem, e.g. $J(w^*) =$. If not needed leave it blank, **not to be ommited**.

The last two defined problem parameters, `\label{optimizationProblem}` and `optimizationResult`, could be made optional. However, in order to improve the problem readability, line breaking between the 7 parametes was implemented; unfortunately, linea breaking and optional parameters are not compatible and these two parameters had to be made mandatory.

2.2 Adding Constraints

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

```
\addConstraint{LHS.k}{RHS.k\label{Const.k}}{extraConst.k}
```

The command accepts three different parameters

1. `LHS.k`: the left-hand side of the the constraint k , e.g. $3w^\top w$.
2. (Optional) `RHS.k\label{Const.k}`: the right-hand side of the constraint k if the equations should be aligned in the equality or inequality signs, e.g. $\leq \|w\|_\infty$. If required, the constraint label should also be included in this term.
3. (Optional) `extraConst.k`: optional parameter to add extra alignment point for additional constraint information. An example would be the constraint names. Look Example 7.9 or the fourth described feature in Section 5.

2.2.1 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!** environment. The label of the objective function can also be included in a similar way.

3 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:

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

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

Additionally, there are four basic definitions of optimization problems:

1. The **mini** environment:

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

2. The **maxi** environment:

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

3. The **argmini** environment:

$$\begin{aligned} &\arg \min_{w} && f(w) + R(w + 6x) \\ &\text{subject to} && g(w) = 0 \end{aligned} \tag{5}$$

4. The **argmaxi** environment:

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

4 Long and Short Output Formats

The library permits the definition of two different problem size: a long format and a short format.

4.1 Long Format

Selected by `sizeFormat=l`. It makes use of *subject to* and *minimize/maximize*

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

4.2 Short Format

Selected by `sizeFormat=s`. It uses instead the shorter *s.t.* and *min/max*

$$\begin{array}{ll}\min_{\underset{w}{w}} & f(w) + R(w + 6x) \\ \text{s.t.} & g(w) = 0\end{array}$$

5 Alignment of Equations

1. Alignment at the beginning of the words *minimize* and *subject to*:

$$\begin{array}{ll}\underset{w}{\text{minimize}} & f(w) + R(w + 6x) \\ \text{subject to} & g(w) = 0\end{array} \tag{7}$$

2. (Optional) Alignment at the =, >, < signs of the constraints.

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

3. (Optional) Alignment of the longest constraint and the objective function:

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

4. (Optional) Third alignment point on the constraints to set some constraint features. A clear example could be the constraints names:

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

or the index of the constraints:

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

6 Output Formats for the Constraints

There are four basic output formats for the location of the constraints. They are controlled by the environment parameter `constraintFormat`.

6.1 Standard Format

It is the default format and if `constraintFormat` left blank it is used. Alternatively can be also set by selecting `constraintFormat=0`.

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

$$\begin{aligned} & \underset{w}{\text{minimize}} && f(w) + R(w + 6x) \\ & \text{subject to} && g(w) + h(w) = 0, \\ & && t(w) = 0. \end{aligned} \tag{8}$$

6.2 Alternative 1

Selected by `constraintFormat=1`. It locates the constraints below *subject to* and keeps them aligned at the inequality/equality signs:

$$\begin{aligned} & \underset{w}{\text{minimize}} && f(w) + R(w + 6x) \\ & \text{subject to} && \\ & && g(w) + h(w) = 0, \\ & && t(w) = 0. \end{aligned} \tag{9}$$

6.3 Alternative 2

Selected by `constraintFormat=2`. It aligns all the constraints with the objective function.

$$\begin{aligned} & \underset{w}{\text{minimize}} && f(w) + R(w + 6x) \\ & \text{subject to} && g(w) + h(w) = 0, \\ & && t(w) = 0. \end{aligned} \tag{10}$$

6.4 Alternative 3

Selected by `constraintFormat=3`. It aligns all the constraints below *subject to*:

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

7 Examples

7.1 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:

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

7.2 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:

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

7.3 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!}

```

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

$$\text{subject to} \quad g(w) = 0, \tag{13b}$$

$$n(w) = 6, \tag{13c}$$

$$L(w) + r(x) = Kw + p, \tag{13d}$$

$$h(x) = 0. \tag{13e}$$

7.4 Example 4 - 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:

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

7.5 Example 5 - Short Format

Adding the short format parameter:

```

\begin{mini}|s|
{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:

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

7.6 Example 6 - Alternative 1 for Constraints

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:

$$\begin{aligned}
& \underset{w}{\text{minimize}} && f(w) + R(w + 6x) \\
& \text{subject to} && \\
& && g(w) = 0, \\
& && n(w) = 6, \\
& && L(w) + r(x) = Kw + p, \\
& && h(x) = 0.
\end{aligned} \tag{16}$$

7.7 Example 7 - Alternative 2 for Constraints

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:

$$\begin{aligned}
& \underset{w}{\text{minimize}} && f(w) + R(w + 6x) \\
& \text{subject to} && g(w) = 0, \\
& && n(w) = 6, \\
& && L(w) + r(x) = Kw + p, \\
& && h(x) = 0.
\end{aligned} \tag{17}$$

7.8 Example 8 - Alternative 3 for Constraints

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:

$$\begin{aligned}
& \underset{w}{\text{minimize}} && f(w) + R(w + 6x) \\
& \text{subject to} && \\
& g(w) = 0, && \\
& n(w) = 6, && \\
& L(w) + r(x) = Kw + p, && \\
& h(x) = 0. &&
\end{aligned} \tag{18}$$

7.9 Example 9 - Extra Alignment in the Constraints

Adding 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*}
```

7.10 Example 10 - 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:

```
\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:

$$\begin{aligned}
w^* &= \arg \min_w && f(w) + R(w + 6x) \\
&\text{subject to} && \\
& g(w) = 0, && \\
& n(w) = 6, && \\
& L(w) + r(x) = Kw + p, && \\
& h(x) = 0. &&
\end{aligned} \tag{19}$$

7.11 Example 11 - 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:

$$\begin{aligned}
& \underset{w}{\text{maximize}} && f(w) + R(w + 6x) \\
& \text{subject to} && g(w) = 0, \\
& && n(w) = 6, \\
& && L(w) + r(x) = Kw + p, \\
& && h(x) = 0.
\end{aligned} \tag{20}$$

7.12 Example 12 - All Possible Parameters

```
\begin{mini*}|s|[1]
{w}{f(w)+ R(w+6x)}
{}{w^*=}
\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*}
```

$$w^* = \min_w f(w) + R(w + 6x) \tag{21a}$$

$$\text{s.t.} \quad g(w) = 0, \tag{21b}$$

$$n(w) = 6, \tag{21c}$$

$$L(w) + r(x) = Kw + p, \tag{21d}$$

$$h(x) = 0. \tag{21e}$$

8 Long Optimization Variables

The standard appearance for long optimization variables is as follows:

$$x_0, u_0, x_1, \dots, u_{N-1}, x_N \quad \begin{array}{l} \text{minimize} \\ \sum_{k=0}^{N-1} L(x_k, u_k) + E(x_N) \end{array} \quad (22a)$$

$$\text{subject to} \quad x_{k+1} - f(x_k, u_k) = 0, \quad k = 0, \dots, N-1, \quad (22b)$$

$$h(x_k, u_k) \leq 0, \quad k = 0, \dots, N-1, \quad (22c)$$

$$r(x_0, x_N) = 0. \quad (22d)$$

A possible way to reduce the large variable spacing is to stack them with the command:

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

$$\begin{array}{l} \text{minimize} \\ x_0, u_0, x_1, \dots, \\ u_{N-1}, x_N \end{array} \quad \sum_{k=0}^{N-1} L(x_k, u_k) + E(x_N) \quad (23a)$$

$$\text{subject to} \quad x_{k+1} - f(x_k, u_k) = 0, \quad k = 0, \dots, N-1, \quad (23b)$$

$$h(x_k, u_k) \leq 0, \quad k = 0, \dots, N-1, \quad (23c)$$

$$r(x_0, x_N) = 0. \quad (23d)$$

9 Code definition

```
% optidef - Version 2.0
%
% 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}[2016/08/07 – version=2.0,
    Package for defining optimization problems]

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

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% DEFINING PACKAGE OPTIONS
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Default
\newcommand{\defaultProblemFormat}{l}

\DeclareOption{short}{
\renewcommand{\defaultProblemFormat}{s}
}

\DeclareOption{long}{
\renewcommand{\defaultProblemFormat}{l}
}

\ProcessOptions\relax

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% VARIABLES DEFINITION
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% 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}{}

% Variable used to define the subject to word for short
% and long versions

```

```

\newcommand{\bodySubjectTo}{\Unset Subject to}

% Variable used for defining if the long problem format
% or the short problem format is used
\newcommand{\localProblemFormat}{1}

% Variable to storage which type of of local problem is
% being solved
\newcommand{\localProblemType}{minimize}

% Defining variable to storage problem variable
\newcommand{\localOptimalVariable}{}

\newlength\stextwidth

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% OBJECTIVE COMMAND DEFINITION
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
\newcommand{\bodyobj}[4]
{
\ifthenelse{\isempty{#4}}
{
&\underset{\displaystyle #1}{\mathrlap{\mathrm{#3}}}\phantom{\mathrm{subject~to}} \quad #2\span\span\span\span
}
{
#4~ &\underset{\displaystyle #1}{\mathrlap{\mathrm{#3}}}\phantom{\mathrm{subject~to}} \quad #2\span\span\span\span
}
}
}

%% LONG VERSION "minimize" instead of "min"
\newcommand{\bodyobjLong}[4]
{
\ifthenelse{\isempty{#4}}
{
&\mathmakebox[\widthof{\$ \underset{\displaystyle #1}{\mathrm{subject~to}}\$}]{\underset{\displaystyle #1}{\mathrm{#3}}} \quad #2\span\span\span\span
}
{
#4~ &\mathmakebox[\widthof{\$ \underset{\displaystyle #1}{\mathrm{subject~to}}\$}]{\underset{\displaystyle #1}{\mathrm{#3}}} \quad #2\span\span\span\span
}
}
}

```



```

%% SHORT VERSION "min" instead of "minimize"
\newcommand{\bodyobjShort}[4]
{
\ifthenelse{\isempty{#4}}
{
&\underset{\displaystyle #1}{\mathrm{#3}} \quad #2\span\span\span\span
}
{
#4 ~ &\underset{\displaystyle #1}{\mathrm{#3}} \quad #2\span\span\span\span
}
}
}

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

%% A BODY CONSTRAINT IS THE INITIAL CONSTRAINT DEFINED
%% WITH THE 'SUBJECT TO', DEPENDING ON THE TYPE OF
%% PROBLEM A DIFFERENT VERSION IS USED

% Main command. Dynamically redefined at every new
% problem definition.
\DeclareDocumentCommand{\bodyconst}{m G{} }
{
\ifthenelse{\equal{#2}{}}{
\\ &\underset{\displaystyle \phantom{\localOptimalVariable}}{\mathrm{subject~to}} \quad \&\#1
#2
}{
\\ &\underset{\displaystyle \phantom{\localOptimalVariable}}{\mathrm{subject~to}} \quad \&\#1
& #2
}
}

\newcommand{\bodySubjectToDefinition}{
%%% If the short version of "subject to", i.e. "s.t.",
% should be used the command \bodySubjectTo should be
% modified
\ifthenelse{\equal{\localProblemFormat}{s}}
{%%
\global\def\bodySubjectTo{\mathmakebox[\widthof{\$}\underset{\displaystyle \phantom{\localOptimalVariable}}{\mathrm{\localProblemType}}\$][c]{\mathmakebox[\widthof{\$}\mathrm{\localProblemType}}\$][l]{\mathrm{\kern 0.1em s.t.}}}}
{%%
\global\def\bodySubjectTo{\mathmakebox[\widthof{\$}\

```

```

underset{\displaystyle \phantom{\localOptimalVariable
}}{\mathrm{\,subject~to}}$][c]{\mathmakebox[\widthof
{$\mathrm{\localProblemType}$}][l]{\mathrm{subject~to
}}}}
}%%
%
}

% Standard version.
\DeclareDocumentCommand{\bodyconstRight}{m G{} G{}}
{%%
\bodySubjectToDefinition
### Set the first constraint according to the format
used for "subject to"
\ifthenelse{\equal{#3}{} }{%%
\ifthenelse{\equal{#2}{} }{
\& \bodySubjectTo \quad \&\#1 \#2
}{%
\& \bodySubjectTo \quad \&\#1 & \#2
}%
\togglefalse{previousThird}
}{%%
\ifthenelse{\equal{#2}{} }{
\& \bodySubjectTo \quad \&\#1 \#2 \&\#3
}{%
\& \bodySubjectTo \quad \&\#1 & \#2 \&\#3
}%
\toggletrue{previousThird}
}%%
}%%%

% Single alignment point but next to subject to
\DeclareDocumentCommand{\bodyconstOneAlign}{m G{} G{}}
{
\bodySubjectToDefinition
### Set the first constraint according to the format
used for "subject to"
\ifthenelse{\equal{#3}{} }{
\& \bodySubjectTo\quad \&\#1 \#2 \&\#3
\togglefalse{previousThird}
}{
\& \bodySubjectTo\quad \&\#1 \#2 \&\#3
\toggletrue{previousThird}
}
}

% Constraints below subject to and with a single alignment
point
\DeclareDocumentCommand{\bodyconstOneAlignBelow}{m G{} G

```

```

    {}
  {
    \bodySubjectToDefinition
    ### Set the first constraint according to the format
      used for "subject to"
    \ifthenelse{\equal{#3}{} }{
      \\\ &\bodySubjectTo \span\span\span\span \\\
      &&#1 #2 \togglefalse{previousThird}
    }{
      \\\ &\bodySubjectTo \span\span\span\span \\\
      &&#1 #2 &&#3
      \toggletrue{previousThird}
    }
  }

  % Constraints below subject to but with double alignment
  point
  \DeclareDocumentCommand{\bodyconstBelow}{m G{} G{}}
  {
    \bodySubjectToDefinition
    ### Set the first constraint according to the format
      used for "subject to"
    \ifthenelse{\equal{#3}{} }{
      \ifthenelse{\equal{#2}{} }{
        \\\ &\bodySubjectTo\span\span\span\span \\\
        &&#1 #2
      }{
        \\\ &\bodySubjectTo \span\span\span\span \\\
        &&#1 & #2
      }
    }
    \togglefalse{previousThird}
  }{
    \ifthenelse{\equal{#2}{} }{
      \\\ &\bodySubjectTo \span\span\span\span \\\
      &&#1 #2 &&#3
    }{
      \\\ &\bodySubjectTo\span\span\span\span \\\
      &&#1 & #2 &&#3
    }
  }
  \toggletrue{previousThird}
}

% Constraints below subject to for the case of having a
reference/label for each individual equation
\DeclareDocumentCommand{\bodyconstBelowMult}{m G{} G{}}
{
  \bodySubjectToDefinition
  ### Set the first constraint according to the format
    used for "subject to"

```



```

    defining extra constraint information is used
\ifthenelse{\equal{#3}{}}{
% Second "If clause" selecting whether two or 1 elements
  for the constraints are used
\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 with a single alignment point but
next to subject to
\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 \&\quad #3
\toggletrue{previousThird}
}
\togglefalse{bodyCon}
}
}

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

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

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% COMMANDS TO DEFINE ALL REQUIRED PROPERTIES TO CHOOSE
% SHORT/LONG FORMAT
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
\newcommand{\setFormatShort}[1]{\global\def\
localProblemFormat{s} \let\bodyobj\bodyobjShort \
renewcommand{\localProblemType}{#1}}

\newcommand{\setFormatLong}[1]{\global\def\
localProblemFormat{l} \let\bodyobj\bodyobjLong \
renewcommand{\localProblemType}{#1}}

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

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%MINIMIZATION ENVIRONMENTS
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% BASE ENVIRONMENTS
% Base environment for the three possible types of
% referencing: 1 label, no label or multilabel
% Base environment defined using NewEnviron package
% because of \BODY command
\NewEnviron{BaseMini}[6]{%
\selectConstraint{#1}
\renewcommand{\localOptimalVariable}{#2}
\begin{equation}
#4
\begin{alignedat}{5}
\bodyobj{#2}{#3}{#6}{#5}
\BODY
\end{alignedat}

```

```

\end{equation}
\setStandardMini
}

```

```

\NewEnviron{BaseMiniStar}[5]{%
\selectConstraint{#1}
\renewcommand{\localOptimalVariable}{#2}
\begin{alignat*}{5}
\bodyobj{#2}{#3}{#5}{#4}
\BODY
\end{alignat*}
\setStandardMini
}

```

```

\NewEnviron{BaseMiniExclam}[6]{%
\selectConstraintMult{#1}
\renewcommand{\localOptimalVariable}{#2}
\begin{subequations}
#4
\begin{alignat}{5}
\bodyobj{#2}{#3}{#6}{#5}
\BODY
\end{alignat}
\end{subequations}
\setStandardMini
}

```

*% INDIVIDUAL AND SPECIFIC ENVIRONMENTS (mini, maxi,
argmini*...)*
*% Specific environments defined with xparse package due
to arguments options*

%MINIMIZATION ENVIRONMENTS
% Single reference probems
\DeclareDocumentEnvironment{mini}{D||{\
defaultProblemFormat} O{0} m m m m}
{\ifthenelse{\equal{#1}{s}}
% Short version problem
{\setFormatShort{min} \BaseMini{#2}{#3}{#4}{#5}{#6}{min}}
% Long version problem
{\setFormatLong{minimize} \BaseMini{#2}{#3}{#4}{#5}{#6}{
minimize}}}
{\endBaseMini}

\DeclareDocumentEnvironment{argmini}{D||{\
defaultProblemFormat} O{0} m m m m}
{\ifthenelse{\equal{#1}{s}}
% Short version problem

```

{\setFormatShort{arg~min} \BaseMini{#2}{#3}{#4}{#5}{#6}{
  arg~min}}
% Long version problem
{\setFormatLong{arg~min} \BaseMini{#2}{#3}{#4}{#5}{#6}{
  arg~min}}
}{\endBaseMini}

% No reference
\DeclareDocumentEnvironment{mini*}{D||{\
  defaultProblemFormat} O{0} m m m m}
{\ifthenelse{\equal{#1}{s}}
% Short version problem
{\setFormatShort{min} \BaseMiniStar{#2}{#3}{#4}{#6}{min}}
% Long version problem
{\setFormatLong{minimize} \BaseMiniStar{#2}{#3}{#4}{#6}{
  minimize}}
}{\textbf{\endBaseMiniStar}}

\DeclareDocumentEnvironment{argmini*}{D||{1} O{0} m m m m}
{
\ifthenelse{\equal{#1}{s}}
% Short problem
{\setFormatShort{arg~min}\BaseMiniStar{#2}{#3}{#4}{#6}{
  arg~min}}
% Long version problem
{\setFormatLong{arg~min} \BaseMiniStar{#2}{#3}{#4}{#6}{
  arg~min}}
}{\textbf{\endBaseMiniStar}}

% Multiple reference
\DeclareDocumentEnvironment{mini!}{D||{\
  defaultProblemFormat} O{0} m m m m}
{\ifthenelse{\equal{#1}{s}}
% Short version problem
{\setFormatShort{min} \BaseMiniExclam
  {#2}{#3}{#4}{#5}{#6}{min}}
% Long version problem
{\setFormatLong{minimize} \BaseMiniExclam
  {#2}{#3}{#4}{#5}{#6}{minimize}}
}{\endBaseMiniExclam}

\DeclareDocumentEnvironment{argmini!}{D||{\
  defaultProblemFormat} O{0} m m m m}
{\ifthenelse{\equal{#1}{s}}
% Short version problem
{\setFormatShort{arg~min}\BaseMiniExclam
  {#2}{#3}{#4}{#5}{#6}{arg~min}}
% Long version problem

```

```

{\setFormatLong{arg~min} \BaseMiniExclam
  {\#2}{\#3}{\#4}{\#5}{\#6}{arg~min}}
}{\endBaseMiniExclam}

```

%MAXIMIZATION ENVIRONMENTS

```

% Single reference problems
\DeclareDocumentEnvironment{maxi}{D||{\
  defaultProblemFormat} O{0} m m m m}
{\ifthenelse{\equal{\#1}{s}}
% Short version problem
{\setFormatShort{max} \BaseMini{\#2}{\#3}{\#4}{\#5}{\#6}{max}}
% Long version problem
{\setFormatLong{maximize} \BaseMini{\#2}{\#3}{\#4}{\#5}{\#6}{
  maximize}}
}{\endBaseMini}

\DeclareDocumentEnvironment{argmaxi}{D||{\
  defaultProblemFormat} O{0} m m m m}
{\ifthenelse{\equal{\#1}{s}}
% Short version problem
{\setFormatShort{arg~max} \BaseMini{\#2}{\#3}{\#4}{\#5}{\#6}{
  arg~max}}
% Long version problem
{\setFormatLong{arg~max} \BaseMini{\#2}{\#3}{\#4}{\#5}{\#6}{
  arg~max}}
}{\endBaseMini}

% No reference
\DeclareDocumentEnvironment{maxi*}{D||{\
  defaultProblemFormat} O{0} m m m m}
{\ifthenelse{\equal{\#1}{s}}
% Short version problem
{\setFormatShort{max} \BaseMiniStar{\#2}{\#3}{\#4}{\#6}{max}}
% Long version problem
{\setFormatLong{maximize} \BaseMiniStar{\#2}{\#3}{\#4}{\#6}{
  maximize}}
}{\textbf{\endBaseMiniStar}}

\DeclareDocumentEnvironment{argmaxi*}{D||{\ 1} O{0} m m m m}
{
}
{\ifthenelse{\equal{\#1}{s}}
% Short version problem
{\setFormatShort{arg~max}\BaseMiniStar{\#2}{\#3}{\#4}{\#6}{
  arg~max}}
% Long version problem

```

```
{\setFormatLong{arg~max} \BaseMiniStar{#2}{#3}{#4}{#6}{
  arg~max}}
}{\textbf{\endBaseMiniStar}}
```

```
% Multiple reference
\DeclareDocumentEnvironment{maxi!}{D||{\
  defaultProblemFormat} O{0} m m m m}
{\ifthenelse{\equal{#1}{s}}
% Short version problem
{\setFormatShort{max} \BaseMiniExclam
  {#2}{#3}{#4}{#5}{#6}{max}}
% Long version problem
{\setFormatLong{maximize} \BaseMiniExclam
  {#2}{#3}{#4}{#5}{#6}{maximize}}
}{\endBaseMiniExclam}
```

```
\DeclareDocumentEnvironment{argmaxi!}{D||{\
  defaultProblemFormat} O{0} m m m m}
{\ifthenelse{\equal{#1}{s}}
% Short version problem
{\setFormatShort{arg~max}\BaseMiniExclam
  {#2}{#3}{#4}{#5}{#6}{arg~max}}
% Long version problem
{\setFormatLong{arg~max} \BaseMiniExclam
  {#2}{#3}{#4}{#5}{#6}{arg~max}}
}{\endBaseMiniExclam}
```