

ARM Lite: Pipelined CPU

Verilog Implementation with Hazard Detection and Forwarding

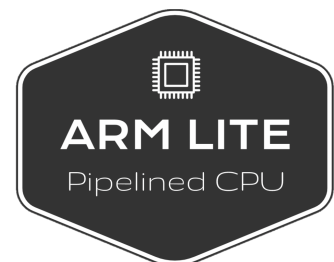
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Version: 2.0

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Project Website: arm-lite.teddy-van-jerry.org

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Preface

Before you comb through the contents of **ARM Lite** CPU design, a brief understanding of systematic design work is like can be beneficial. The impression of developing this project is that it is by no means easy but the whole system we build rewards us with great fulfillment. This project features the pipelined CPU with hazard detection and forwarding, which leads to a lot of difficulty in implementation.

The project uses Verilog on Xilinx Vivado 2017.4 and has been tested both on Ubuntu and Windows. Apart from the hardware implementation of the CPU, the project also contains a compiler that translates ARM (64-bit) code into machine code using C++.

The authors would like to thank Man Feng and Xudong Ma for their assistance for their guidance and assistance in pipelined CPU design. This work is originally the course project for DIGITAL DESIGN AND COMPUTER ARCHITECTURE, 2021 Fall of Southeast University.

There may be errors in this project and you are welcome to pull request on GitHub or contact the author via E-Mail: wqzhao@seu.edu.cn.

Wuqiong Zhao

Jan. 7, 2022

At Southeast University

Chapter 1 Brief Introduction

1.1 Project Host Information

The project of ARM Lite is open source and hosted on GitHub: github.com/Teddy-van-Jerry/ARM_Lite with the official website at arm-lite.teddy-van-jerry.org.

You can fork the project repository or download source code at the release page.

1.2 Project Target

Chapter 2 Elegant \LaTeX Templates

Elegant \LaTeX Program developers are intended to provide you beautiful, elegant, user-friendly templates. Currently, the Elegant \LaTeX is composed of **ElegantNote**, **ElegantBook**, **ElegantPaper**, designed for typesetting notes, books, and working papers respectively. Latest releases are strongly recommended! This guide is aimed at briefly introducing the 101 of this template. For any other question, suggestion or comment, feel free to contact us on GitHub **issues** or email us at **elegantlatex2e@gmail.com**.

Contact Infos:

- Homepage: <https://elegantlatex.org/>
- GitHub: <https://github.com/ElegantLaTeX/>
- CTAN: <https://ctan.org/pkg/elegantbook>
- Wiki: <https://github.com/ElegantLaTeX/ElegantBook/wiki>
- Download: **release**, **latest version**
- Weibo: Elegant \LaTeX
- Wechat: Elegant \LaTeX
- QQ: 692108391
- Email: **elegantlatex2e@gmail.com**

2.1 ElegantBook Updates

Version 4.1 is the first version of 3.x, we add support for biblatex, theorem, and multilingual translation. What's new in this version:

1. **! Big Change**: Change the bibliography method from \BibTeX to biblatex(with backend biber);
2. **! Big Change**: Add support for the default theorem writing method (with optional name and label);
3. Add left and right space;
4. Support hyperlink from the text of TOC;
5. Remove the pdf \LaTeX compatibility check for Chinese.
6. Add multilingual support, for french **lang=fr**, dutch **lang=nl**, Hungarian **lang=hu**, Spanish **lang=es**, Mongolian **lang=mn** etc.

2.2 Installation and Update

Both portable version and installation package are available, online usage is optional as well.

2.2.1 To Use Templates Online

Visit **Overleaf** to use our template online anywhere and anytime without local installation. To find our template, search elegantlatex in the templates or simply visit **search result**, choose the template you prefer and Open as Template to own a copy yourself to edit freely. To learn more about Overleaf, please refer to **Documentation**.

Remark On Overleaf, please use \XeLaTeX to compile articles in Chinese and pdf \LaTeX to compile articles in English.

2.2.2 To Use Portable Version

For portable version, simply download latest ElegantBook-master from GitHub or CTAN (to be more accurate, download `elegantbook.cls`) and save the file(s) under your working directory. This way of installation is simple and convenient, but you have to manually update `cls` now and then.

2.2.3 Update Templates

If you fail to update templates using `tlshell`, please use `cmd` to update all the packages or switch to portable version instead.

Use the following commands(administrator privileges) to update:

```
tlmgr update --self
tlmgr update --all
```

To learn more, please refer to [How do I update my T_EX distribution?](#)

2.2.4 Other Release Versions

If you are a T_EX Live 2018/2019/2020 user and would like to update, the official solution is to uninstall the previous version. If you want to save the bother of uninstallation and re-installation, please copy `elegantbook.cls` to the installation directory of T_EX Live 2021 (default: `C:\texlive\2021\texmf-dist\tex\latex\elephantbook`), run `texhash` in `cmd`.

2.3 About Pull Request

For some reasons, pull requests will NOT be accepted since May 20, 2019. For those who want to help improve the templates, submit issues or clone to your own repository to modify under LPPL-1.3c.

Chapter 3 ElegantBook Settings

This template is based on the Standard L^AT_EX book class, so the options of book class work as well (Note that the option of papersize has no effect due to `device` option). The default encoding is UTF-8 while T_EX Live is recommended. The test environment is Win10 + T_EX Live 2021, either pdfL^AT_EX or XeL^AT_EX works fine. XeL^AT_EX is preferred for Chinese articles.

3.1 Languages

We defined one option named `lang` which has two basic values, `lang=en` (default) , `lang=cn`. Different values will alter the captions of figure/table, abstract name, refname, etc. You can use this option as

```
\documentclass[en]{elegantbook}
\documentclass[lang=en]{elegantbook}
```

Besides the two basic language translation, our user provide more options, here is a short brief introduction to these translation. Since I am not familiar with these languages, I can't guarantee that the translations are correct, please comment on GitHub if you have some questions.

- Italian translation `lang=it`, provided by [VincentMVV](#) , please refer to [Italian translation](#);
- French translation `lang=fr`, provided by [abfek66](#) , please refer to [Italian translation](#);
- Dutch Translation `lang=nl`, provided by [inktviz75](#) , please refer to [Dutch Translation](#);
- Hungarian translation `lang=hu`, provided by [palkotamas](#), please refer to [Hungarian translation](#);
- Deutsch translation `lang=de`, provided by Lisa, please refer to [Deutsch translation](#);
- Spanish translation `lang=es`, provided by Gustavo A. Corradi, please refer to [Spanish translation](#);
- Mongolian translation `lang=mn`, provided by [Altantsooj](#), please refer to [Mongolian translation](#).

Remark Chinese Characters are acceptable **ONLY** in `lang=cn`.

3.2 Device Mode Option

The option for device (`device`) was originally used in ElegantNote, now we include this option in ElegantBook¹ as well. Activate iPad mode in the following way²:

```
\documentclass[iPad]{elegantbook} %or
\documentclass[device=iPad]{elegantbook}
```

3.3 Color Themes

This template contains 5 color themes, i.e. `green`³, `cyan`, `blue`(default), `gray`, `black`. You can choose `green` with





















¹Pictures have to be modified accordingly.

²Default size: normal, A4 paper.

³Original default theme.

```
\documentclass[green]{elegantbook} %or
\documentclass[color=green]{elegantbook}
```

Table 3.1: ElegantBook Themes

	green	cyan	blue	gray	black	Main Environments
structure						chapter section subsection
main						definition exercise problem
second						theorem lemma corollary
third						proposition

If you want to customize the colors, please select `nocolor` or use `color=none` and declare the main, second, and third colors in the preamble section as follows:

```
\definecolor{structurecolor}{RGB}{60,113,183}
\definecolor{main}{RGB}{0,166,82}%
\definecolor{second}{RGB}{255,134,24}%
\definecolor{third}{RGB}{0,174,247}%
```

3.4 Cover

3.4.1 Customized Cover

From v3.10, customized cover is allowed, you can choose or hide any element as you prefer. Current optional elements are:

- title: `\title`
- subtitle: `\subtitle`
- author: `\author`
- institute: `\institute`
- date: `\date`
- version: `\version`
- extra information: `\extrainfo`
- cover image: `\cover`
- logo: `\logo`

Besides, an extra command `\bioinfo` is provided with two options—caption and content. For instance, if you want to display Username: 111520, just type in

```
\bioinfo{Username}{111520}
```

You can change the color of the horizontal bar of the cover by


```
\definecolor{customcolor}{RGB}{32,178,170}
\colorlet{coverlinecolor}{customcolor}
```

3.4.2 Cover Image

The cover image used in this template is from [pixabay.com](https://www.pixabay.com). The image is completely free and can be used under any circumstance. The cover image size is 1280×1024 . If you would like to change the cover, please crop it according to the size of the cover picture strictly. One free online image clipping site: [fotor.com](https://www.fotor.com). Feel free to join our QQ Group to get more elegant covers.

3.4.3 Logo

Aspect ratio of the logo is 1:1 in this guide, i.e. a square picture. To replace the logo, do remember to choose the appropriate picture.

3.4.4 Stylized Cover

Want to use stylized cover?(For instance, A4-sized PDF designed by Adobe Illustrator) Please comment out `\maketitle` and use `pdfpages` to insert the cover. Similar for using `titlepage`. If you would like to use the cover in version 2.x, please refer to [etitlepage](#).

3.5 Chapter Title Display Styles

This template contains 2 sets of *title display styles*, `hang`(default) and `display` style. For the former, chapter title is displayed on a single line (`hang`). For the latter, chapter title is displayed on a double line (`display`). In this guide, we use `hang`. To change display style, use:

```
\documentclass[hang]{elegantbook} %or
\documentclass[titlestyle=hang]{elegantbook}
```

3.6 Introduction of Math Environments

We defined two sets of theorem modes, `simple` style and `fancy` style (default). You may change to `simple` mode by

```
\documentclass[simple]{elegantbook} %or
\documentclass[mode=simple]{elegantbook}
```

In this template, we defined four different theorem class environments

- *Theorem Environment*, including title and content, numbering corresponding to chapter. Three types depending on the format:
 - **definition** environment, the color is **main**;
 - **theorem, lemma, corollary** environment, the color is **second**;
 - **proposition** environment, the color is **third**.

- *Example Environments*, including **example**, **exercise**, **problem** environment, auto numbering corresponding to chapter.
- *Proof Environment*, including **proof**, **note** environment containing introductory symbol (**note** environment) or ending symbol (**proof** environment).
- *Conclusion Environments*, including **conclusion**, **assumption**, **property**, **remark** and **solution**⁴ environments, all of which begin with boldfaced words, with format consistent with normal paragraphs.

3.6.1 Theorem Class Environments

Since the template uses the `tcolorbox` package to customize the theorem class environments, it is slightly different from the normal theorem environments. The usage is as follows:

```
\begin{theorem}{theorem name}{label text}
The content of theorem.
\end{theorem}
```

The first parameter `<theorem name>` represents the name of the theorem, and the second parameter `label` represents the label used in cross-reference with `ref{thm:label}`. Note that cross-references must be prefixed with `thm:`.

From version 4.1, you can write your theorem environments as follows:

```
\begin{theorem}[theorem name]\label{thm:label text}
The content of theorem.
\end{theorem}
% or
\begin{theorem}
The content of theorem.
\end{theorem}
```

Other theorem class environments with the same usage includes:

Table 3.2: Theorem Class Environments

Environment	Label text	Prefix	Cross-reference
definition	label	def	<code>\ref{def:label}</code>
theorem	label	thm	<code>\ref{thm:label}</code>
lemma	label	lem	<code>\ref{lem:label}</code>
corrlary	label	cor	<code>\ref{cor:label}</code>
proposition	label	pro	<code>\ref{pro:label}</code>

3.6.2 Other Customized Environments

The other three math environments can be called directly since there are no additional option for them, e.g. example:

```
\begin{example}
This is the content of example environment.
```

⁴We also define an option `result`, which can hide the `solution` and `proof` environments. You can switch between `result=answer` and `result=noanswer`.

```
\end{example}
```

The effect is as follows:

Example 3.1 This is the content of example environment.

These are all similar environments with slight differences lies in:

- Example, exercise, problem environments number within chapter;
- Note begins with introductory symbol and proof ends with ending symbol;
- Conclusion and other environments are normal paragraph environments with boldfaced introductory words.

3.7 List Environments

This template uses `tikz` to customize the list environments, with `itemize` environment customized to the third depth and `enumerate` environment customized to fourth depth. The effect is as follows

- | | |
|---|--|
| <ul style="list-style-type: none"> • first item of nesti; • second item of nesti; <ul style="list-style-type: none"> • first item of nestii; • second item of nestii; <ul style="list-style-type: none"> • first item of nestiii; • second item of nestiii. | <ol style="list-style-type: none"> 1. first item of nesti; 2. second item of nesti; <ol style="list-style-type: none"> (a). first item of nestii; (b). second item of nestii; <ol style="list-style-type: none"> I. first item of nestiii; II. second item of nestiii. |
|---|--|

3.8 Fonts

Alert After v3.10, newtx is reset to cm, together with other two options, the `math` font option offers:

1. `math=cm`(default), use L^AT_EX default math font (recommended).
2. `math=newtx`, use `newtxmath` math font (may bring about bugs).
3. `math=mtpro2`, use `mtpro2` package to set math font.

If you use newtx fonts, type in:

```
\documentclass[math=newtx]{elegantbook}
```

When you are using newtx, please pay attention to the hyphens. For instance,

$$\int_{R^q} f(x,y)dy.off \quad (3.1)$$

The corresponding code is:

```
\begin{equation}
\int_{R^q} f(x,y) dy.\emph{of \kern0pt f}
\end{equation}
```

3.8.1 Symbol Fonts

Feedback from some 3.08 users claims that error occurs when using our templates with `yhmth`, `esvect` and other packages.

LaTeX Error:
Too many symbol fonts declared.

The reason is that the template redefines font for math so that no new math font is allowed to be added. To use `yhmath` and/or `esvect`, please locate `yhmath` or `esvect` in `elegantbook.cls`, uncomment corresponding related code.

```
%%% use yhmath pkg, uncomment following code
% \let\oldwidering\widering
% \let\widering\undefined
% \RequirePackage{yhmath}
% \let\widering\oldwidering

%%% use esvect pkg, uncomment following code
% \RequirePackage{esvect}
```

3.9 Bibliography

This template uses `biblatex` to generate the bibliography, the default `citestyle` and `bibstyle` are both `numeric`. Let's take a glance at the citation effect. `[en1]` use data from a major peer-to-peer lending `[en3]` marketplace in China to study whether female and male investors evaluate loan performance differently `[en2]`.

If you want to use `biblatex`, you must create a file named `reference.bib`, add `bib` items (from Google Scholar, Mendeley, EndNote, and etc.) to `reference.bib` file, then cite the `bibkey` in the `tex` file. The `biber` will automatically generate the bibliography for the reference you cited.

To change the bibliography style, this version introduces `citestyle` and `bibstyle`, please refer to [CTAN:biblatex](#) for more detail about these options. You can change your bibliography style as

```
\documentclass[citestyle=numeric-comp, bibstyle=authoryear]{elegantbook}
```

3.10 Preface

If you want to add a preface before the first chapter with the number of chapter unchanged, please add the preface in the following way:

```
\chapter*{Introduction}
\markboth{Introduction}{Introduction}
The content of introduction.
```

3.11 Content Option and Depth

Option for content `toc`, you can choose either one column(`onecol`) or two columns(`twocol`). For two columns:

```
\documentclass[twocol]{elegantbook}
\documentclass[toc=twocol]{elegantbook}
```

Default content depth is 1, use to use `\setcounter{tocdepth}{2}`.

3.12 Introduction Environment

We create a introduction environment to display the structure of chapter. The basic useage is as follows:

```
\begin{introduction}
  \item Definition of Theorem
  \item Ask for help
  \item Optimization Problem
  \item Property of Cauchy Series
  \item Angle of Corner
\end{introduction}
```

And you will get:

Introduction	
<input type="checkbox"/> <i>Definition of Theorem</i>	<input type="checkbox"/> <i>Property of Cauchy Series</i>
<input type="checkbox"/> <i>Ask for help</i>	<input type="checkbox"/> <i>Angle of Corner</i>
<input type="checkbox"/> <i>Optimization Problem</i>	

You can change the title of this environment by modifying the optional argument of this environment:

```
\begin{introduction}[Brief Introduction]
...
\end{introduction}
```

The environment `problemset` is used at the end of each chapter to display corresponding exercises. Just type in the following sentences:

```
\begin{problemset}
  \item exercise 1
  \item exercise 2
  \item exercise 3
\end{problemset}
```

And you will get:

Chapter 3 Exercise

1. exercise 1
2. exercise 2
3. exercise 3
4. math equation test:

$$a^2 + b^2 = c_{2_i}(1, 2)[1, 23] \quad (3.2)$$

Remark If you want to customize the title of `problemset`, please change the optional argument like in introduction environment. In this version the `problemset` environment automatically appears in the table of contents but not in the header or footer(to be fixed).

Solution If you want to customize the title of `problemset`, please change the optional argument like in introduction environment. In this version the `problemset` environment automatically appears in the table of contents but not in the header or footer(to be fixed).

3.13 Margin Notes

In 3.08, we introduced `marginpar=margintrue` and `\elegantpar` (Beta) with piles of bugs. Hence we decide to remove them in 3.09 and will suspend the options till revolutionary optimization. Sorry for all the bugs! However, we retain the option `marginpar` for users to get margin notes by activating `marginpar=margintrue` and using `\marginpar` or `marginnote` packages.

Remark Note that text and equation are both available in the margin notes.

```
% text
\marginpar{margin paragraph text}

% equation
\marginpar{
\begin{equation}
a^2 + b^2 = c^2
\end{equation}
}
```

For tables and figures, note that floating environment is not allowed. You have to use `includegraphics` or `table` and use `\captionof` to name it. To get centralized figures or tables, use `\centerline` or `center`. To learn more, please refer to [Caption of Figure in Marginpar](#).

```
% graph with centerline command
\marginpar{
\centerline{
\includegraphics[width=0.2\textwidth]{logo.png}
}
\captionof{figure}{your figure caption}
}

% graph with center environment
\marginpar{
\begin{center}
\includegraphics[width=0.2\textwidth]{logo.png}
\captionof{figure}{your figure caption}
\end{center}
}
```

Chapter 4 ElegantBook Writing Sample

Introduction

❑ Theorem Class Envrionments

❑ Cross Reference

❑ Math Environments

❑ List Environments

❑ Logo and Base

❑ $a^2 + b^2 = c^2$

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetur id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

4.1 Writing Sample

We will define the integral of a measurable function in three steps. First, we define the integral of a nonnegative simple function. Let E be the measurable set in \mathcal{R}^N .

Definition 4.1 (Left Coset)

Let H be a subgroup of a group G . A left coset of H in G is a subset of G that is of the form xH , where $x \in G$ and $xH = \{xh : h \in H\}$. Similarly a right coset of H in G is a subset of G that is of the form Hx , where $Hx = \{hx : h \in H\}$



Note Note that a subgroup H of a group G is itself a left coset of H in G .

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Theorem 4.1 (Lagrange's Theorem)

Let G be a finite group, and let H be a subgroup of G . Then the order of H divides the order of G .



4.1 Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec

et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

Proposition 4.1 (Size of Left Coset)

Let H be a finite subgroup of a group G . Then each left coset of H in G has the same number of elements as H .

Proof Let z be some element of $xH \cap yH$. Then $z = xa$ for some $a \in H$, and $z = yb$ for some $b \in H$. If h is any element of H then $ah \in H$ and $a^{-1}h \in H$, since H is a subgroup of G . But $zh = x(ah)$ and $xh = z(a^{-1}h)$ for all $h \in H$. Therefore $zH \subset xH$ and $xH \subset zH$, and thus $xH = zH$. Similarly $yH = zH$, and thus $xH = yH$, as required.

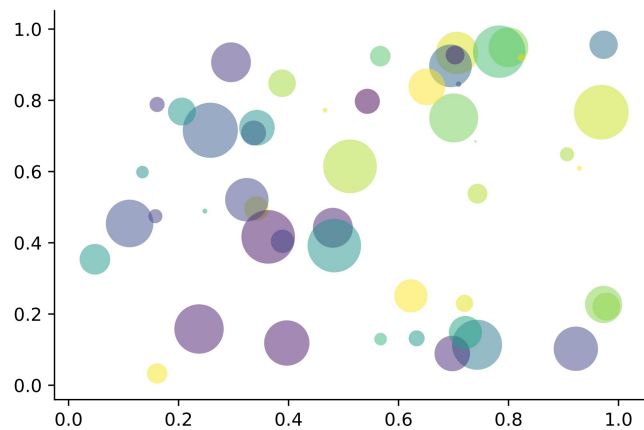


Figure 4.1: Matplotlib: Scatter Plot Example

Regression analysis is a powerful statistical method that allows you to examine the relationship between two or more variables of interest. While there are many types of regression analysis, at their core they all examine the influence of one or more independent variables on a dependent variable. The process of performing a regression allows you to confidently determine which factors matter most, which factors can be ignored, and how these factors influence each other.

Let's continue using our application training example. In this case, we'd want to measure the historical levels of satisfaction with the events from the past three years or so, as well as any information possible in regards to the independent variables.

4.2 Second section

This second section may include some special word, and expand the ones already used.

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetur id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Table 4.1: Auto MPG and Price

	(1)	(2)
mpg	-238.90*** (53.08)	-49.51 (86.16)
weight		1.75*** (0.641)
constant	11,253*** (1,171)	1,946 (3,597)
obs	74	74
R^2	0.220	0.293

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

- Routing and resource discovery;
 - Language Models
 - Vector Space Models
- Resilient and scalable computer networks;
- Distributed storage and search.

Chapter 4 Exercise

1. Solve the equation $5(-3x - 2) - (x - 3) = -4(4x + 5) + 13$.
2. Find the distance between the points $(-4, -5)$ and $(-1, -1)$.
3. Find the slope of the line $5x - 5y = 7$.

Chapter 5 FAQ

We list some FAQs for users to refer to:

1. *Why option numbers for natbib fail to take effect in v3.07?*

In v3.07, when gbt7714 is introduced, option authoryear is incompatible with `natbib`. In v3.08 and 3.09, numbers, numbers, super and authoryear are introduced.

2. *I want to customize font and background color.*

Please use `pagecolor` to change background color, refer to `this` to customize font.

3. *Which version should I choose?*

Please use **Latest Release** via GitHub or T_EX Live 2021.

4. *Which editor should I choose?*

You can use T_EX Live 2021 built-in T_EXworks or T_EXstudio. You may refer to **T_EXworks autocomplete**. T_EX Live 2021 + T_EXstudio is strongly recommended. I myself use VS Code and Sublime Text. Related configurations can be found at **vscode-latex** and **sublime-text-latex**.

5. *Hello, we want to use ElegantBook to write a book about machine learning and would like your authorization.*

Feel free to use our templates by pointing out our copyright. For other issues, please refer to LPPL-1.3c. If you want to show us your work, share the URL with us afterwards.

6. *What is cross reference?*

This template is aimed at who are not a complete beginner for L^AT_EX. Please learn more about L^AT_EX before using this template.

7. *Is the language for code highlighting optional?*

Yes, `listings` package is used in ElegantBook, hence language is optional(e.g. `language=Python`). For global setting, use `lstset`. For more information, please refer to package documentations.

8. *When will Beamer template (ElegantSlide or ElegantBeamer) forthcoming?*

Since there is an excellent theme **Metropolis**, no plan for Beamer theme.

Chapter 6 Version History

We revised our project now and then. This section shows the version story of ARM Lite. We have 24 commits and 2 releases on GitHub.

2022/01/07 *Updates:release of v2.0*

①

2021/12/24 *Updates:release of v1.1*

①

2021/12/23 *Updates:release of v1.0*

- ① Work based on **ARM-LEGv8** (pipelined with hazard detection and forwarding) is implemented on Xilinx Vivado 2017.4 both on Ubuntu and Windows.
- ② Create the Visio Drawing for the CPU architecture.

Appendix A Mathematical Tools

This appendix covers some of the basic mathematics used in econometrics. We briefly discuss the properties of summation operators, study the properties of linear and some nonlinear equations, and review the ratios and percentages. We also introduce some special functions that are common in econometrics applications, including quadratic functions and natural logarithms. The first four sections require only basic algebraic techniques. The fifth section briefly reviews differential Calculus. Although Calculus is not necessary to understand much of this book, it is used in some of the end-of-chapter appendices and in some of the more advanced topics in part 3.

A.1 Summation Operator and Description Statistics

Summation Operator is an abbreviation used to express the summation of numbers, it plays an important role in statistics and econometrics analysis. If $\{x_i : i = 1, 2, \dots, n\}$ is a sequence of n numbers, the summation of the n numbers is:

$$\sum_{i=1}^n x_i \equiv x_1 + x_2 + \dots + x_n \quad (\text{A.1})$$