



UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH

Escola Superior d'Enginyeries Industrial,
Aeroespacial i Audiovisual de Terrassa

BACHELOR THESIS

BACHELOR'S DEGREE IN AEROSPACE VEHICLE ENGINEERING

HEAT AND MASS TRANSFER TECHNOLOGICAL CENTER

Study for the numerical resolution of the Navier-Stokes equations using the Fractional Step Method

BUDGET

POLYTECHNIC UNIVERSITY OF CATALONIA
ESEIAAT

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Delivery Date:
10th June 2018

1 Introduction

This document presents the estimated budget of the study, dividing the costs into direct and indirect costs.

2 Justification of costs

The main task of this project consists in programming *Matlab* codes. Therefore, the direct costs shall be high due to a great amount hours of engineering work and, on the other hand, indirect costs shall be low.

2.1 Direct costs

Direct costs are those which are traceable to the production of a specific good or service. They involve all related costs to the project development, such as study, investigation, programming, memory writing, etc.

This part of study has been carried out by a non-graduated aerospace engineering student during 5 months, from 23.01.2018 to 10.06.2018, working an average of 25 hours a week. The hourly payment of an engineer in such situation is difficult to estimate. Therefore, these costs are computed using a reference cost per hour for a junior engineer: 15 euros per hour.

Direct costs include:

- Investigation and theory study: Within the total time of the realization of this project, a lot of time has been devoted to the research and study of the theory behind numerical methods, Fractional Step Method, etc.
- Programming hours: In this project it is necessary to dominate a programming language. In this case, *Matlab* is used to design the code and to carry out data analysis. Learning how to use *Matlab* in a correct way has represented an important time expense.
- Lesson hours: The CTTC offered many lessons to correctly understand numerical methods, the Fractional Step Method, codes validation and verification, etc.
- Data analysis: After finishing each code, much time has been spent processing, analyzing and comparing data; as well as graphically representing them.
- Memory writing

The direct costs are presented in the following table:

Table 1: Direct costs.

Concept	Time (h)	Price/hour (€)	Price (€)
Investigation and theory study	25	15	375
Attended lessons	15	15	225
Subtotal	40		600
Code development			
2D Transient Conduction	50	15	750
1D Convection-Diffusion (1)	15	15	225
1D Convection-Diffusion (2)	5	15	75
Diagonal Flow	15	15	225
Smith - Hutton	10	15	150
Driven Cavity	65	15	975
Differentially Heated Cavity	10	15	150
Subtotal	170		2550
Data analysis			
Microsoft Excel	30	15	450
Matlab	40	15	600
Subtotal	70		1050
Documents elaboration			
Report	190	15	2850
Budget	10	15	150
Annex	5	15	75
Subtotal	205		3075
TOTAL	485		7275

2.2 Indirect costs

Indirect costs may be necessary for production, but they are not traceable to the act of production itself. Indirect costs are those necessary to keep the study in operation.

Indirect costs include:

- Software: This includes all program and software licenses needed during the study. All licenses used to carry out this study are student licenses. IVA is included in all software prices.
- Energy resources: This part of indirect costs basically takes into account the electricity consumed by the computer along the study. The total hours in which the computer has been active are taken into account ¹.

¹The average power consumption of a computer, as referenced in [1], is 15 kWh per month.

- Printing of documents

The indirect costs are presented in the following Table:

Table 2: Indirect costs.

Concept	Description	Units	Price/unit (€)	Price (€)
Matlab License	Annual Student	1	250	250
Microsoft Office License	Office Students 16	1	150	150
ShareLateX PRO License	Annual Student	1	70	70
Energy resources	Electricity	$15 \cdot 5 = 75$	0,15	11
Printing of documents	–	1	30	30
TOTAL				511

2.3 Total costs

The balance of all costs is, approximately, 7800 (€) as we can see in next Table:

Table 3: Total costs.

Direct Costs (€)	7275
Indirect Costs (€)	511
TOTAL (€)	7786

References

- [1] HP. *IT ECO Declarations: Desktop PCs*. 2018. URL: <https://bit.ly/2xNB31E>.