Labor-Cost-Schedule Document

Engineering + Entrepreneurship Intrapreneurship Content

EE 4390 Senior Design

image https://www.henson.com/

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Objectives

- Learn about
  - Gantt charts for project management, scheduling, tracking, communicating
  - Labor types and associated costs
  - Direct and indirect project costs
- and how these apply to Senior Design
- Learn how to construct a schedule with dependencies
- Review the template you will use to construct your Labor-Cost-Schedule document

Background

Labor, Cost & Schedule (LCS) is extremely important in development and taking a product to market

- **Labor** – what types of skills, and how many person-hours, are needed to succeed
- **Cost** – what will the development cost?
- **Schedule** – how long will it take? What are the dependencies?

While a LCS estimate may sound like something for the business development team, **the engineers often are involved in its creation**.

Why Important to Us?

It models a real-world development

- Marketable ideas are great, but -
- How long will it take and is it affordable?!?

It is a valuable skill for employment

- As an engineer you will participate in the creation of schedules and cost estimates
- You will be expected to follow schedules and hit budgets!

It is an ABET accreditation requirement

- A *"…curriculum culminating in a* **major design experience** *based on the knowledge and skills acquired in* earlier course work *and incorporating appropriate* **engineering standards** *and* **multiple realistic constraints***"* includes creating and understanding a LCS

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Project Management: Gantt Charts

Gantt charts show project tasks, milestones, and dependencies

They are produced using project management software – not Excel or Word

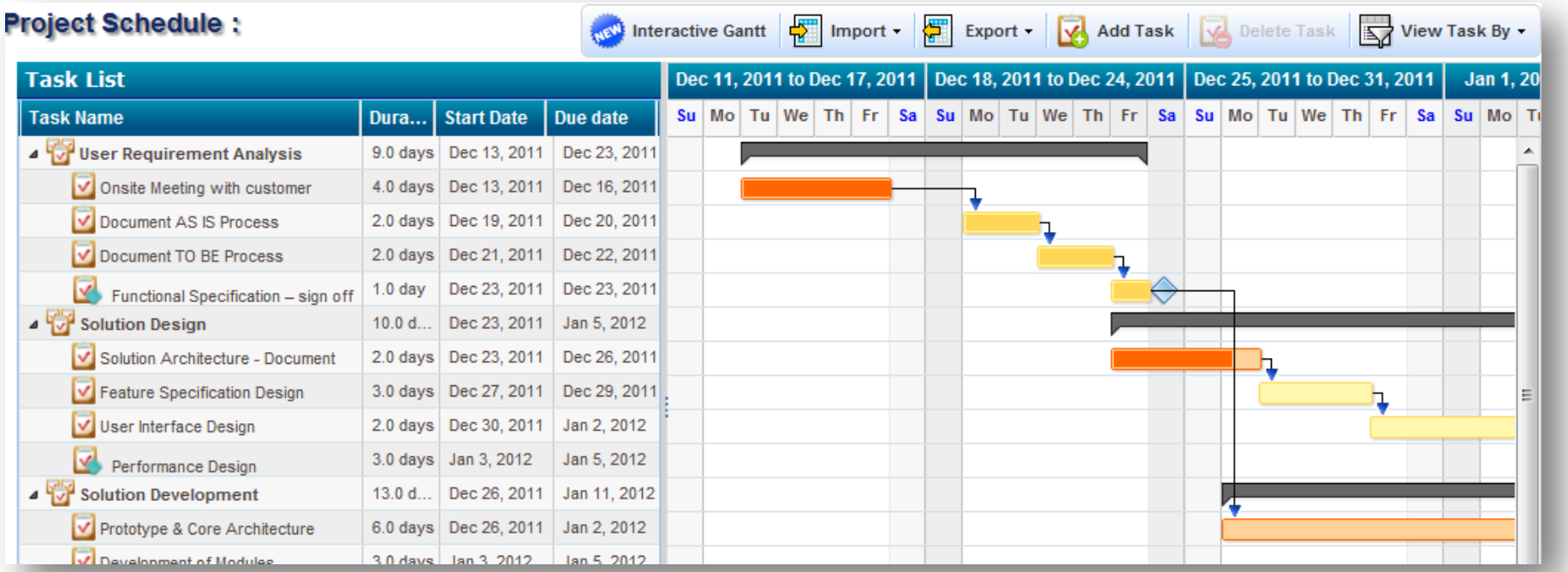

image http://blog.zilicus.com/wp-content/uploads/2012/06/ZilicusPM-3.01.png

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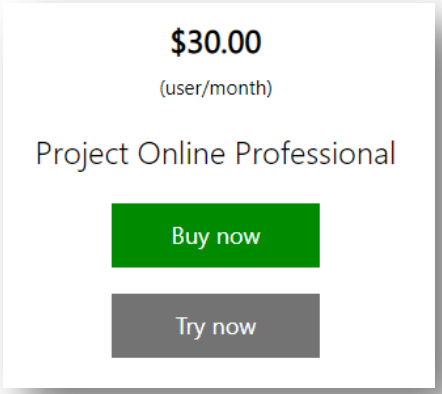
Microsoft Project is a common tool for creating Gantt charts and managing projects

It is not difficult to use and is very scalable, but subscription priced

Licensed for TXState computers only, free trial is also available



https://products.office.com/en-us/project/compare-microsoft-project-management-software

Many other options – you can use whatever works best for you as long as your Gantt chart is correct and looks professional

If you find a good alternative let us know!

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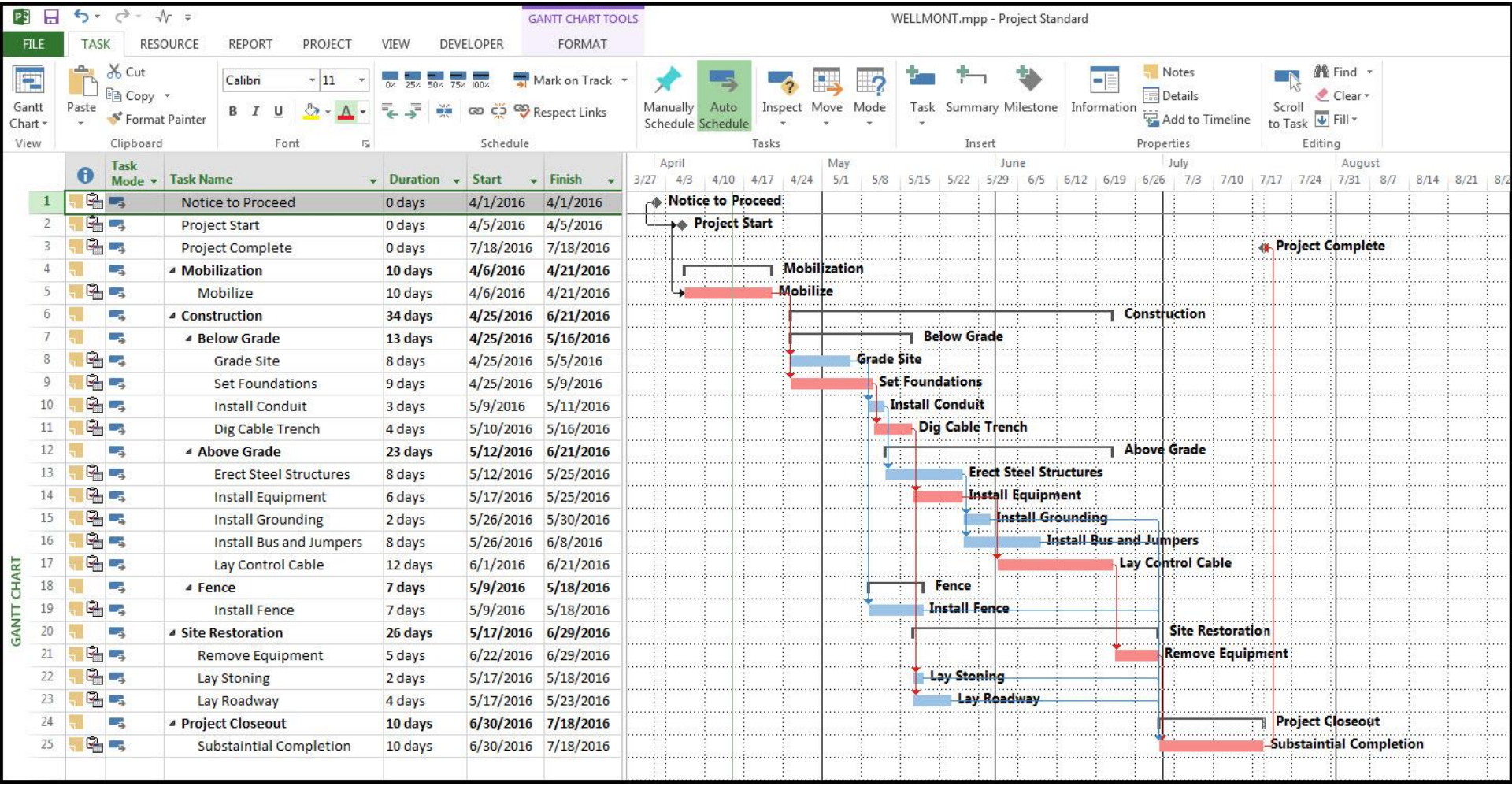
Example Microsoft Project Gantt chart

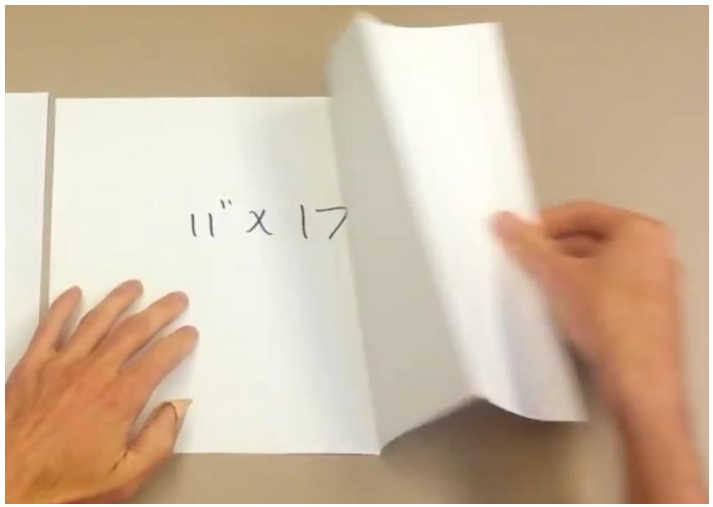


More training options on Lynda.com
https://www.lynda.com/Project-tutorials/Microsoft-Project-2019-Project-Online-Desktop-Essential-Training/716043-2.html
https://www.lynda.com/Charts-Graphs-tutorials/Gantt-Charts-Explained/365730-2.html

Print out Gantt Chart on 11x17” paper

- If not on this size and/or unreadable = FAIL the document
- Increment must be **WEEKS!**
  - **Days or months = unacceptable**
- Fold in half, then fold top portion back

https://www.youtube.com/watch?v=cK1ZbYiHky8



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“Takes money to make money”

For all products you will have project expense (R&D)

- Engineers, Project Managers, Testers, Contractors, etc
- Prototype expense
- Non-Recurring Engineering Expenses (NRE) e.g. pay supplier to layout PCB

For products going into production they will have unit costs

Cost of Goods Sold (COGS) = cost/unit x #units

- Components – Bill of Materials (BOM)
- Manufacturing and test expense – typically bid or allocated
- Boxes, buns, manuals, power cords, etc.
- Reserves for service and warranty obligations
- Shipping especially if overseas factory (e.g. ship to warehouse vs customer)

If all costs that can be directly linked or allocated to the manufacture of a product are accounted for this is called the “fully burdened cost”

Expenses

We will consider 3 major expense categories:

Labor

- Cost of salaries
- Contractors and consultants

Non-Capital Expenditures

- Materials & components that will be used up in the process

Capital Expenditures

- Equipment needed for development that costs more than $5,000 and will last at least a year; often used on more than one project

Labor Types

Many different types of labor may be required for a given engineering development.

Not all developments will include all labor types.

Each labor type may have a different hourly cost.

Labor Types for LCS

Typical Labor Categories and Hourly Costs	
Labor Category	**Hourly Burdened Cost**
Design Engineer	
Test Engineer	
Technical Writer	
Technician	
Fabricator / Assembler	
Drafting / CAD	
Marketing Analyst	
Administrative	
Management / Supervision	
Consulting	

Note that this table was intentionally left blank!

You may not have all these labor types!!!

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Labor Costs

Research or estimate the hourly costs for Labor relevant to your project.

Recall there are ***2080 working hours/year***.

Note that these costs are likely 'unburdened'

- benefits and overhead costs are not factored into the cost
- The actual cost per employee may be twice that of the hourly rate! This is the burdened rate.

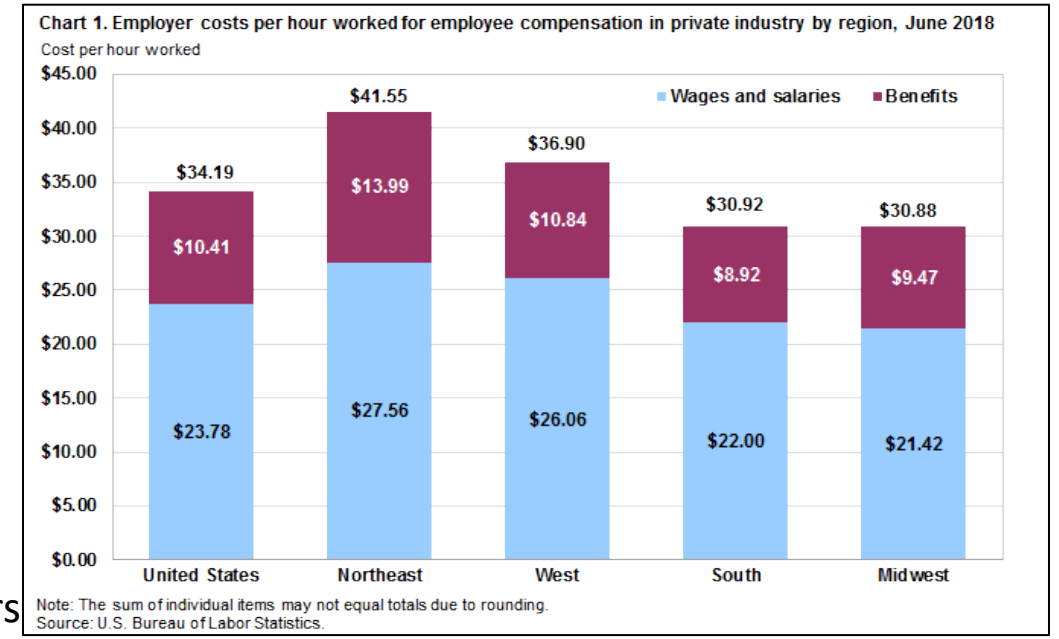
Burdened Salary

Consider the case where a company is paying an engineer a given salary. The actual cost to the company is much higher, as the company must pay costs such as:

- Health/dental/vision/life-STD-LTD
- Social security and Medicare
- Federal/State Unemp Insurance
- PTO/Sick leave
- Paid vacation and holidays
- 401K match

plus other expenses

- Lease on the building and grounds
- Heating & AC
- Electricity
- Computing infrastructure
- Office furniture with ergonomic chairs
- Security
- ***... the list goes on.***



The degree of burden varies depending upon the company. Startups often have lower overhead thus lower burden. If labor is readily available part time positions may be used to avoid some benefits costs.

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More About Burdened Salary

Burden is usually expressed as a percentage, indicating what percent of direct cost goes to overhead.

Labor Burden Rate = Indirect Costs / Direct Payroll Costs

A 50% burden rate is not unusual

- Cost to company is 50% more than employee's wages
- This 50% goes to benefits, employer portion of social security taxes, etc.
- Example: if $60k/yr goes to the employee then $30k/yr goes to overhead for that same employee.

Thus, the $60k/yr salary employee costs the company $90k/yr, or $90k/2080 = $43/hr

Burden applies to ALL labor categories except contracting or consulting.

Example Burden Breakdown

Labor Cost Estimate - Wages, Taxes, Benefits

Electrical Engineer Mean Hourly Wage	$47.87	https://www.bls.gov/oes/current/oes172071.htm
Annual Wage (2080 hrs)	$99,570	
Social Security Tax (6.2% comp & 6.2% emp)	$6,173	https://www.irs.gov/taxtopics/tc751
Medicare Tax (1.45% comp & 1.45% emp)	$1,444	
Texas Unemployment Tax (2.7% 1st $9K)	$243	https://twc.texas.gov/businesses/unemployment-insurance-tax-rates
Medical (employer paid)	$16,125	benefits est'd Austin area, 2014 family coverage
Dental	$1,009	
Vision	$139	
Basic Life Insurance	$60	
Short Term Disability	$235	
Long Term Disability	$442	
AD&D	$12	
Paid Time Off (15 days)	$5,744	
Paid Company Holidays (10 days)	$3,830	
401K Match (6%)	$5,974	
Total Employer Paid Taxes & Benefits	$41,430	
Cost to Employer - Wages + Taxes + Benefits	$141,000	

Estimated "take home"	
Wages	$99,570
Employee SS and Medicare	-$7,617
Est. Federal Inc Tax*	-$5,402
Employee Paid Medical etc.	-$8,637
401K contribution	-$5,974
Total	$71,940

*Tax estimate married filing jointly, 2 dependents from https://apps.irs.gov/app/withholdingcalculator/index.jsp

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Contractors & Consultants

Are typically used for development when there is a special or non-ongoing need (also common to contract out functions such as food services, custodial services, IT, etc)

Can be a firm or individual, usually charge by the hour

- That's what you pay – it will be higher than just wages
- They carry their own burden internally

Contractor firms may or may not offer benefits to their employees

You cannot treat contractors as employees

ref https://www.irs.gov/newsroom/understanding-employee-vs-contractor-designation

Contractors & Consultants can be terminated with little notice or obligation

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Labor Categories

For each of the categories below you will justify why – or why not – your project requires that labor category.

You may add categories as needed.

Don't forget to THINK.

Project Labor Categories	
Labor Category	**Justification**
Design Engineer	Gee – you definitely have this one!
Test Engineer	Better test your design!
Technical Writer	Aren't there tech docs for this class?
Technician	
Fabricator / Assembler	Are ya gonna build anything physical?
Drafting / CAD	
Marketing Analyst	
Administrative	
Management / Supervision	Doesn't the PM do some management?
Consulting	Sponsor/Instructors do some of this?
Contractor	

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Burdened Labor Costs

For each of the labor categories **USED IN YOUR PROJECT** and exemplified below you will give a burdened hourly cost.

Do a bit of research to try and get reasonable numbers, both for wage and burden. Don't make it a career, though!

Labor Categories and Burdened Hourly Costs	
Labor Category	**Burdened Hourly Cost**
Design Engineer	
Test Engineer	
Technical Writer	
Technician	
Fabricator / Assembler	
Drafting / CAD	
Marketing Analyst	
Administrative	
Management / Supervision	
Consulting	
Contractor	

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More Burdened Labor Costs

- Research and estimate what a labor type pays

- **Example**: According to glassdoor.com, the average salary for a VLSI Design Engineer is $91,451
- Divide by 2080 to get hourly wage: $43.97/hour (just use $44)
- If the burden rate is 50% multiply by 1.5x = $66/hour

- ***An engineer with a $91,451 annual salary will cost the company $66/hour***

Total Labor Cost

This table in the Template lists

- Tasks as rows
- Labor types & costs as columns
- Shows at a glance the # of hours, and costs, required

Do NOT copy the contents of this table they are only examples!

LABOR ESTIMATE				
	Engineer	**Test Engr**	**Fabricator**	**TOTAL**
Burdened Hourly Rate	**$100**	**$80**	**$40**	
Task	Hours Required			
Project definition	20			$2,000
Functional Specification	20	5		$2,400
Simulation	40			$4,000
Test Plan	10	20		$2,600
Prototype Assembly	5	5	40	$2,500
Characterization	10	30		$3,400
Total Burdened Cost				$35,400

You may need to define a page (section) to be landscape mode in your LCS document to accommodate this table.

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Your Project Labor – Use BRAIN

Figure it out!

- You work 13 weeks in D1
- There are 14 weeks in D2

Your plan should therefore allow for 27 weeks of labor

For a 3-credit class you are expected to work 9 hours/week

Labor hours = # team members * 9 hours/week * 27 weeks
= 243 hours/person

- Example: 3 person team = 729 person-hours

- At $66/hour, labor for these three engineers would cost $48,114!

- ***This is a MINIMUM***

Other individuals

You may wish to include labor for persons other than students such as:

- Faculty Advisor(s)
- Instructor(s)
- Technical aid from sponsoring company
- etc

This is not a requirement – just be mindful

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Multiple Hats

DO NOT DUPLICATE LABOR!

For example, the PM might consider some of his or her time as **Management / Supervision**

- This is fine
- **But his or her time should still add up to ~ 245 hours for the project**

Materials

- Some engineering developments may require materials for purposes of
  - Prototype construction
  - Test bed
  - Demonstration units
  - And may include items such as PC boards, connectors, sensors, cables, chips, passive components, displays, etc.

Types of material costs

There are two main categories of costs we will use

Non-Capital Expenditures

- Less than $5k, “used up”
- Components to build prototypes or demo units
- Supplies and small equipment for verification & testing
- Wire, solder, etc.

Capital Expenditures

- Major purchases with cost of $5k or more per single item
- Has value over multiple year timeframe
- e.g. lab instruments, test stations, computers, furniture

  May or may not be project-specific
  - The corporate logic analyzer is used on several different projects
  - The spectrum analyzer is needed for your project alone (at this time)

Your materials cost section should consider both categories

Non-Capital Expenditures Table

You should be able to forecast the non-capital expenses with high accuracy.
This is the list of the parts that you will need to buy, and, that you will receive from the Sponsor.

NON-CAPITAL EXPENDITURE ESTIMATE		
Task	**Materials**	**Cost**
Simulation	PSPICE for PC	$500
Fabricate prototype	Solder kit	$20
	Cables	$100
	IC's	$200
Test bed	PC board	$75
TOTAL		$900

Do NOT list a Bill of Materials showing every little component!
Just show the totals!

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Capital Expenditures Table

Take your best guess as to what capital expense items are required to complete your project.
Think about what you will use in the lab or testing your sponsor might do for you.
This will increase your awareness of the cost to do a project.

CAPITAL EXPENDITURE ESTIMATE		
Task	**Materials**	**Cost**
Simulation	Hardware accelerator	$7,500[1]
	Disk farm	$75,000[1]
Fabricate prototype	3D printer	$6,000[2]
Test bed	LTX Tester	$8,000,000[1]
TOTAL		

[1] Available from Sponsor
[2] Available at Texas State University

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Total Project Cost - EXAMPLE

Now that you have the cost categories, summarize them in one table.

PROJECT LABOR & MATERIALS COST SUMMARY	
Cost Category	**Estimated Cost**
Labor	$55,400
Capital Expenses	$8,000
Non-Capital Expenses	$2,000
TOTAL ESTIMATED PROJECT COST	$65,400

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PROVEN Ways to Fail This Document

- Getting expense types wrong, e.g., not understanding what Capital is
- Using ALL the labor types when in reality you only have a few
- Grossly underestimating a burdened salary
  - Do you REALLY think you can hire a EE design engineer with 3-5 years experience for $35k/yr?
- Getting the number of student hours wrong
- Incorporating a Bill of Materials showing every little resistor instead of simply categorizing expenditures, e.g., “Components”
- Gantt Chart missing start/end dates, task name, person’s name
- Gantt Chart using interval other than weeks
- Gantt Chart not on 11x17 paper and/or unreadable