GNG 2101 Summary Sheet

Contents

1 Design For X

Functional requirements define what a product should do. DFX (Design for X) allows us to ensure the product meets the certain requirements called X.

Non functional requirements are about How the product does what we want it do do such as the speed, and quality.

DFX allows us to focus on specific goals for the product, one at a time. We want to have discussions about "How do we incorporate X?". Each X has specific design standards and rules that help to incorporate this X.

Some examples are:

- Design for Accessibility
- Design for Reliability
- Design for Testability
- Design for Repairability
- Design for Compliance
- Design for Sustainability
- Design for Maintainability

1.1 Compliance

Compliance constraints are stuff such as health and safety regulations, environmental regulations, quality codes, and standards.

Often devices need to be able to use generic designs such as USB which means they need to comply with these preexisting standards. These standards are usually explained in technical documents.

Government regulations for environment, and health/safety are also critical to avoid fines.

1.2 Sustainability

1.2.1 Triple Bottom Line

Sustainability is a concept that depends on people, profit, and the planet. We need a product to satisfy all three of these concepts for it to be able to be sustainable which is challenging. So we need a balance between all three of these items.

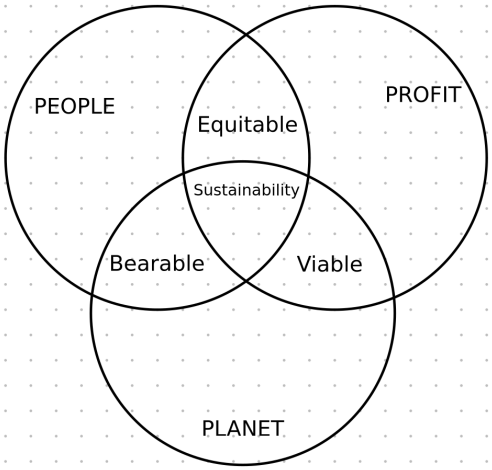

Figure 1: Triple Bottom Line Graphic

1.2.2 Life Cycle Assessment

This is a way to determine the impact of a certain device over its life cycle from when it is created in the factory (or before), to when it goes into the landfill (or potentially after). We analyze the inputs, outputs, and potential environmental impacts of the product over its lifetime.

We start by determining the frame of the LCA analysis, we can either do:

- Cradle to Grave - From raw materials to end of life
- Cradle to Gate - From raw materials to gate of manufacturing facility (before transportation to consumer)
- Cradle to Cradle - From raw materials, to end of life, and then it is recycled into new raw materials

We have a bunch of stages in the LCA analysis such as:

- Raw materials acquisition
- Materials manufacture
- Product manufacture
- Product use / Consumption
- Disposing of product (recycling, or dump)

1.2.3 Normalization

This is a way to calculate greenhouse gas emissions using a standard metric. This allows us to fairly compare products to other products to see which products create the least emissions.

1.3 Manufacturability

2 Concept Development Process

We have a few different design processes such as:

- Waterfall - Sequential process
- Agile - Iteratively create a prototype, get feedback, then find solution, and repeat
- Spiral - Similar to agile method with different prototypes solving iterative problems, but we add risk analysis
- Co-Evolution - Represents evolution of problem space, and solution space, the problem and solution evolve together, useful for ill defined problems
- Iterative - build $\rightarrow$ test $\rightarrow$ refine $\rightarrow$ repeat

For all of the design methods, to manage the project we have 4 main points:

- Plan - Is the plan well laid out
- Processes - Are the processes well defined
- People - Do we have a good team
- Power - Distribution of authority

We can use a GANTT chart to manage the project, this breaks up the project up into multiple sub-tasks, with estimated completion times, and dependencies identified.

For the Iterative Engineering Design Process (IEDP), we first generate solutions, then check if these solutions satisfy the DFX. If so, we prototype and see if the solution works, if it does not, we go back to the start (generate solutions).

When coming up with the solutions, we need to generate a large amount of them. Then we score these solutions using a decision matrix that contains different factors.

Criteria	**Weight**	**Car A**	**Car B**
Cost	0.5	8	3
Reliability	0.4	3	10
Features	0.1	4	6
Total	1	4+0.4+1.2=5.6	1.5+4+0.6=6.1

Table 1: Decision Matrix Example

3 Prototyping

4 Teamwork

5 Ethics

6 Intellectual Property

7 Economics

7.1 Cost Classifications

When running a business, we can classify costs as either **variable** or **fixed** (or **semi variable**). Then we can also classify them as **direct** or **indirect**.

Indirect vs Direct is whether it directly relates to a specific project or not. If it does relate to a specific project, then it is a direct cost. Otherwise, it is an indirect cost.

Variable vs Fixed is whether the cost scales with output or not. For example, the cost of gas for heating a factory is the same whether we are making 1 item a day, or 1000 items per day. However the cost of materials for 1 item is a lot cheaper than 1000 items.

7.2 Fundamental Concepts

We have two main types of economics. **Macroeconomics** deals with a national economy, and everything within a country. **Microeconomics** deals with *one* person, group, or company. We just focus on this one entities economics.

Money is not static with respect to time, it has a time value. A certain amount of money now is worth less in a year because of **interest**. We have compound interest, or simple interest. They can be calculated as follows:

$$\text{Simple: } (1 + i \cdot a) \cdot C_0$$

$$\text{Compound: } C_0 \cdot \left(1 + \frac{i}{n}\right)^{n \times a}$$

where C_0 is the principle amount, i is the annual interest rate, a is the number of years, and n is the number of interest periods/payments per year.

Due to interest, we can calculate the **Net Present Value (NPV)** of money at a certain time. This is useful since it allows us to account for time when comparing different income opportunities. For example, getting paid 100$ now, or 110$ in 6 months. We can evaluate which one is worth more right now by accounting for the interest we would make on the 100$ over 6 months.

$$PV = \sum \frac{FV}{(1 + \frac{i}{n})^{n \times a}} \qquad \text{OR} \qquad FV = \sum PV(1 + i)^n$$

where PV is the present value, FV is the future value, and the denominator is just the interest calculation.

Depreciation means that new things are worth more than old things. This is especially true with large machines used in business. We use the **straight line depreciation** equation to calculate the cost of an equipment over time.

$$D_L = \frac{\text{Equipment Cost}}{\text{Useful Life}}$$

7.3 Economic Decision Making

To make economic decisions, we have a few different ways.

- Break Even Analysis
- Sensitivity Analysis
- Return on Investment (ROI) and Simple Payback Period
- Cost/Benefit Trade-off Analysis

If we are deciding on whether or not to make or buy a certain product, often the cost to make the product will be less for large quantities of the project, but more for just one product. For example, repairing a mobile phone vs paying someone to do so. If I repair a phone, I need to buy a few hundred dollars of equipment and then I can do the repair for cheap. If I pay someone, I might only pay them 100$ though. If I repair 10 phones, it would be either 1000$, or if I do it myself, a few hundred in equipment and then small material fees.

Break even analysis is the point at which the cost to buy equals the cost to make, or the cost to produce equals the revenue. This is a number. Going to the phone example, if we spend 300$ on tools, and 50$ per phone if I do it, vs 100$ if a shop does it, then at 6 phones, if I do it I spend 600$, vs the shop charges 600$. We consider the break even point 6 phones.

Sensitivity analysis allows us to see the profitability of a certain project in different situations based on varying different variables. So we could say "What if we spend 20% more on development?" or "What if we take an extra week to deploy?" or "What if we sell it for 2$ cheaper?". We could see the impact on the profit for each of these situations.

Return on Investment (ROI) is calculated using:

$$ROI = \frac{\text{Net Profit}}{\text{Value of Investment}} \times 100\%$$

Note that we need to account for the time value of money in this calculation.

The **simple payback period** is the amount of time it takes to recover the initial investment. This does not take into account the time value of money.

$$n_{tot} = \frac{\text{Value of Investment}}{\text{Net profit per period}}$$

Cost/benefit trade off analysis sows is the advantages and disadvantages on both sides.

$$BCR \text{ (Benefit Cost Ratio)} = \frac{\text{PV of Benefits}}{\text{PV of Costs}}$$

7.4 Financial Statements

There are three types of financial statements:

- Balance Sheets (Snapshot of the financial condition at a *certain time*)
- Cash flow statement (Cash in and Cash out over a *period of time*)
- Income Statement (Changes in wealth over a *period of time*)

For the **balance sheet**, we just show the equity which is just the assets - liabilities. Assets include current assets, cash, inventory, long term assets, and depreciation (negative asset). The liabilities are accounts payable, and borrowing. The net worth is the equity (assets - liabilities).

The **cash flow statement** shows the cash in (operations, sales, tax received, borrowing, investments) and the cash out (spending, operation expenditures, bill payments, tax out, asset purchasing, debt paying). We get the net cash flow which is the cash in - cash out.

The **income statement** (profit/loss statement) shows the sales, and expenses to get the profit/loss. We take the sales, and subtract the cost of goods sold and operating expenses. This is the **operating income** (Earnings Before Interest [EBI]). Then once we factor in all interest (a cost to what we are borrowing) we can get the **Earnings Before Taxes (EBT)**. The **Net Income** taxes into account income tax.

8 Appendix