UCLouvain

epl

LMAPR2020: Materials Selection

# First homework on the basics

*Work performed by Group L:*

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# Question 1

Using the selection principle presented in the book :

1. Translation :
   - Constraints:
     - Must be an Hip Hop album
     - Must have song with women and men
   - Objective :
     - Must be as short as possible (Minimize the time)
2. Screening:
   By consulting the available albums we find 4 of them which correspond to the given constraints.
   - My beautiful dark twisted fantasy
   - Watch the throne
   - Good kid, MAAD city
   - Flower boy
3. Ranking:
   The two shortest albums among the four are :
   - Watch the throne (46:12)
   - Flower boy (46:39)

4. Documentation: The most popular album and with the most songs with women and men which also minimizes time is: **Watch the throne**

# Question 2

## a. Make comments to correct or enhance their answers

Functions :

- "Kitchen Spatula" : not precise enough, the function must include the purpose of the object like facilitate cooking by flipping, stirring, and scraping food.

Objectives:

- "Minimize mass" : not really relevant for a kitchen spatula
- "Cheap material" : it is not an objective, it's more like a constraint. Moreover, cheap compared to what, it's not precise.
- "Minimize the price" : the price depends only of the material. But the final product depends of others aspect like the fabrication process.
- The only relevant objective would be "Minimize the cost" since the product must be affordable for everyone and the company's profit must be maximized.

Constraint:

- "High Young's Modulus" : This constraint must be formulated with a threshold value or be expressed with context otherwise it is useless.
- " The polymer should withstand temperatures between-10°C and 100°C" : This constraint specifies a class of material...

Free Variable:

- "Color" : Color is not a free variable in the material selection process because it does not directly affect the functionality of the spatula.

### b. Based on your comments, which of the 3 specifications table is the best one ?

The second specification table seems to be the best one.

### c. Write your own even better version of the kitchen spatula specifications.

Functions:

- Kitchen spatula used to mix, turn and scrape foods without damaging cooking utensils

Objectives:

- Minimize the cost (to be affordable for everyone)

Constraints:

- Non-toxic (Must be compatible with food use, without releasing harmful substances)
- Heat resistant (resist to a $T \geq 200$°C without melting or degrading)

- Relatively high stiffness to mix well without bending excessively.
- Does not plastically deform during stirring
- Withstands normal stresses of use (Should not break or wear out quickly under regular use)

Free variable:

- Thickness
- Material

### d. What differentiates an objective from a constraint ?

A constraint is a limitation or an attribute, whether in the form of a quantity (a number) or rather a standard, that the material must respect. On the other hand, an objective is a goal that we seek to optimize by maximizing or minimizing a specific variable, such as cost or mass.

## Question 3

Home aquarium :

Function:

- A transparent container capable of holding water and supporting small fish.

Objectives:

- Minimize the cost

Constraints:

- Must withstand water pressure
- Transparent for visibility
- Non-toxic to fish and safe for aquatic life
- Corrosion-resistant to ensure longevity
- Completely waterproof to avoid leakage

Free variables:

- Thickness

- Material
- Shape

## Question 4

For a tie we will have a tensile effort which means that:

$$\sigma = \frac{F}{A}$$

$$\frac{F}{A} \leq \sigma_y \text{ with } \sigma_y \text{ the yield strenght}$$

$$m = AL\rho => A = \frac{m}{L\rho}$$

$$\frac{FL\rho}{m} \leq \sigma_y => \frac{FL}{m} \leq \frac{\sigma_y}{\rho}$$

We have to maximize the $\sigma_y/\rho$ indices.

For a beam we will have a flexion effort which means that:

$$\sigma_y = \frac{My}{I} \text{ with } I = \frac{bh^3}{12} \text{ and } \frac{h}{2} = y$$

$$\sigma_y \geq \frac{6M}{bh^2}$$

$$m = LA\rho = Lhb\rho$$

$$\frac{m}{Lb\rho} \geq (\frac{6M}{b\sigma_y})^{\frac{1}{2}} => \frac{\sigma_y^{1/2}}{\rho} \geq (\frac{(6Mb)^{\frac{1}{2}}L}{m})$$

We have to maximize the $\frac{\sigma_y^{1/2}}{\rho}$ indices.

For a tie, the applied force creates a uniform normal stress across the entire cross section. For a beam, the bending moment results in a stress distribution which varies according to the height of the section (maximum at the outer fibers, zero at the neutral fiber). The beam index is therefore based on another relationship between strength and density.

## Question 5

How can we deal the material selection when multiple objectives conflict together and what strategies exist to optimize several objectives at the same time ?