9.6 Constrained design project

Name: _____ Class: _____ Date: _____ **Total: 14 marks**

KEY WORDS weighted decision matrix • design spiral

Objective

Choose a concept with a weighted decision matrix, test how robust the choice is to the weights, and collect the checks of a design into one file that names the governing limit.

1 Key knowledge and worked examples

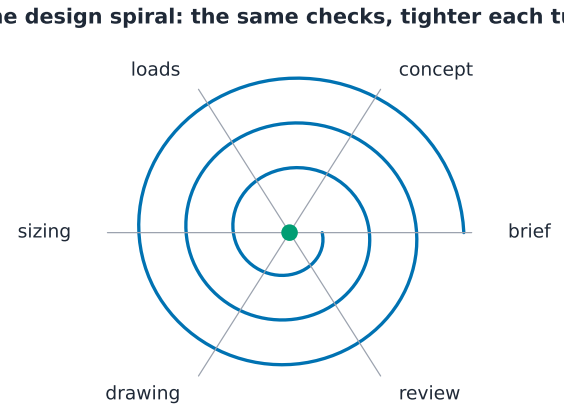
Decide, then check, then turn again

- **Weighted decision matrix** : score each concept 1 to 5 on each criterion, multiply by the weights (summing to 1) and add.
- A choice is robust only if it survives reasonable changes to the weights.
- **Design spiral** : each turn repeats the same checks (shaft, bearings, bolts, gears) with better numbers, and records what is still assumed.

Worked example. Choosing the drive concept

Weights: cost 0.35, size 0.25, efficiency 0.25, maintenance 0.15.

- A spur gears (4, 3, 4, 3): $0.35 \times 4 + 0.25 \times 3 + 0.25 \times 4 + 0.15 \times 3 = \mathbf{3.60}$.
- B belt drive (5, 2, 3, 3): **3.45**; C gearmotor (3, 4, 4, 5): **3.80**.
- C wins on this brief; the design file must say why the course still details A.



2 Practice

A conveyor drive brief weights cost 0.30, size 0.30, efficiency 0.25 and maintenance 0.15. Scores (cost, size, efficiency, maintenance): A spur gears (4, 3, 4, 3); B chain drive (5, 4, 3, 2); C gearmotor (3, 4, 5, 4).

2.1 Find each concept's weighted score (two decimals) and the winner. [4]

2.2 The client now weights cost 0.45, size 0.20, efficiency 0.20 and maintenance 0.15. Recompute and say whether the choice is robust. [4]

3 Exam-style questions

3.1 A design file lists: shaft Goodman $n = 2.13$, shaft yield $n = 3.95$, bearing $L_{10} = 49\,100$ h against 30 000 h required, bolt load factor 4.21, gear bending $n = 1.66$. Turn the bearing life into a factor on load (life $\propto 1/P^3$), name the governing check, and list two assumptions the next turn of the spiral must test. [6]

Solutions

2.1

- A: $0.30 \times 4 + 0.30 \times 3 + 0.25 \times 4 + 0.15 \times 3 = \mathbf{3.55}$.
- B: $0.30{\times}5{+}0.30{\times}4{+}0.25{\times}3{+}0.15{\times}2 = \mathbf{3.75}$; C: $0.30{\times}3{+}0.30{\times}4{+}0.25{\times}5{+}0.15{\times}4 = \mathbf{3.95}$.
- C, the gearmotor, wins.

2.2

- A $= \mathbf{3.65}$; B $= 0.45 \times 5 + 0.20 \times 4 + 0.20 \times 3 + 0.15 \times 2 = \mathbf{3.95}$; C $= \mathbf{3.75}$.
- B now wins: the choice flips with a cost-heavy brief, so it is not robust and the weights must be agreed with the client first.

3.1

- Life ratio $49\,100/30\,000 = 1.64$, so the load could rise by $1.64^{1/3} = \mathbf{1.18}$ before the life falls short.
- The gear's 1.66 is the lowest of the stress factors, but on load the bearing's 1.18 is the tightest margin: it **governs**.
- Assumptions to test: no shock loads; shaft deflection and the key not yet checked; adequate lubrication.