

[Insert Table 1.3 here]

### Problem 3

Two activities are required to evaluate student answers to this question. First you need to look at the concept maps and make sure they have been correctly constructed. You can use the sample mark rubric for this purpose. You need to specify your own weighting for the criteria.

Next you can use the students' maps to assess their knowledge of batch manufacturing. Some features of batch manufacturing that could be included are:

- Definition of batch manufacture.
- Production methods suitable for batch manufacture.
- Factory layouts suitable for batch manufacture.
- Production planning and control methods suitable for batch manufacture.
- Design methods for designing processes and layouts suitable for batch manufacture.
- Organisational structures suitable for batch manufacture.

## **Chapter 2 Designing System Architectures**

### **Teaching Tips**

Students should already have covered the system concepts and system engineering fundamentals. In this chapter we extend the notion of systems to include social systems. You can focus on these aspects, which will be new to engineering students:

- Open system concept defined by four relations - it is important to stress that these do not have to be cause-effect relations; they can be producer-product relations.
- System philosophy - experimentalist philosophy. The chapter gives a brief introduction. In Part II we expand on this in more detail and rename some of the ideals.

- Description of environment and system boundary
- Ackoff's classification of systems
- Alexander's approach

## **Solutions to Exercises and Problems**

### Problem 1

The problem is intended to show students how fragile our modern systems are.

(a)

[Insert Figure 2.1 here]

(b)

Discuss the basic survival rules: 3-3-3. 3 minutes without air and we die. 3 days without water and we die. 3 weeks without food and we die. So the most important input is clean air – air that we can breathe.

Energy is the next important input. This is because there are no manual methods for obtaining clean water or food in a city apartment. Energy is required to clean water and for pumps to supply water. Modern agriculture is heavily dependent on energy to grow, package and distribute food. Energy is required to remove dirty water and waste. Finally, energy is needed to light up the house, drive appliances, and provide a comfortable temperature. Our modern cities are built on cheap and readily accessible energy.

(c)

The point of this part of the question is to show how reliant a modern household is on other systems. When these fail then the household system collapses; as happened after the earthquake in Christchurch, New Zealand and the Japanese tsunami. You might like to

discuss the examples or others closer to your location when reviewing the solution with students.

[Insert Tables 2.1 and 2.2 here]

### Problem 2

Collect the students' work, lay it out in the classroom and ask students to assess the photos for life. Summarise the results. There should be a high degree of consensus regarding the photos that have more life. Discuss the findings with the students.

### Problem 3

There are two aims for this problem. The first aim is to reinforce student's knowledge of graph and matrix representation methods for describing systems. The second aim is to introduce them to natural ecologies.

(a) and (b)

[Insert Figure 2.2 here]

(c) It is a closed system

(d) It is an ecological system. Hunters, herbivores, primary predators and decomposers are animated systems. Plants, litter, timber, and sun are deterministic systems.

### Problem 4

Professional engineers design, build, operate and maintain complex systems needed for society. Professional engineers are held accountable by society if these systems fail.

Therefore they must have systems thinking skills to design, build, operate and maintain the systems effectively.

### Problem 5

This problem is intended to give students practice in developing a verification plan. There is no correct answer. Students must include the mandatory verification requirements specified by the competition organisers. Students can obtain these from the following websites:

Formula Student: <http://www.formulastudent.com/formula-student>

Formula SAE: <http://www.fsaonline.com/>

Nearly all the components will be purchased components, e.g., the engine. They do not need design verification, but should be inspected to ensure they comply with the specifications.

Design verification activities should focus on the components that are made by students and on integration. The following minimal list of activities should be carried out.

[Insert Table 2.3 here]

## **Chapter 3 Product Design**

### **Teaching Tips**

Chapter 2 describes design processes for individual designers and teams of designers. In our view, students should develop competence in both processes.

#### *Individual Design*

You can use our design process called *design as a personal activity* to teach students how to design small assemblies and units. the focus is on creating individual design solutions from inspiration to prototype construction. You can provide a design library of past designs, both good and bad. Students can be encouraged to study these designs and learn from them. The designs can be obtained from company catalogues, design journals and design handbooks. It is also useful to have physical models of design components and sub-systems, as this helps students appreciate the physical consequences of their "paper" or "computer" designs.