MP3004 – CONCURRENT DESIGN AND ENGINEERING

SEMESTER 1 EXAMINATION 2009 – 2010

Question 1

1 (a)

Traditional three sigma are applied only to manufacturing processes, while six sigma is applied to all important business processes, treating manufacturing process as only part of a larger system.

Six sigma is more stringent than traditional three sigma. Six sigma requires a "capable" process to have a standard deviation of no more than one-twelfth of the total allowable spread, as compared to one sixth from traditional three sigma.

Three sigma translates into more non-conforming product (2700PPM), while six sigma translates into only 0.002PPM non-conforming products.

Six sigma philosophies can be applied to engineering or business with the following steps. Firstly, you should perform an observation on some important aspect of your business. Then, you should develop a tentative explanation or hypothesis consistent with your observations.

Based on the hypothesis made, a decision should be made. Your prediction can be tested by conducting experiments or further observations. Your hypothesis should be modified with new facts. These two steps should be repeated until there are no discrepancies between the hypothesis and the results from experiments or observation.

1 (b) (i)

Reliability is one aspect of safety but is not synonymous with it. For example, firepower can be reliable but is inherently unsafe. Poor reliability can cause malfunction and render products unsafe.

There are mainly two aspects which affect the reliability of a product, namely mechanical and material. Mechanical factors that will affect product reliability are buckling, stress concentration, surface finishes, and fasteners, such as nut and bolt, rivets and adhesives. Material factors are residual stress, fatigue life, anisotropy, fracture toughness and corrosion.

1((b) (ii)

Express warranty states that a product will perform in a certain way, for a specific purpose and contains specific safeguards. Implied warranty does not need explicit statements to warrant that any product placed on sale is implied to be safe and suitable for the purpose for which it was sold.

Express warranty spells out the time period the warranty is effective, equipment or parts covered and the extent of free replacement, in terms of labor, material or both. Implied warranty has no such terms.

Implied warranty covers two main areas, fit for ordinary use and for particular purpose. Fit for ordinary use implies that the product is safe to be used in the form it is sold, while fit for particular purpose implies that the product is safe to be used in the purpose recommended by the supplier. Express warranty requires clear statements which indicate the way the product shall perform.

Question 2

2 (a) (i)

The Kano model in QFD is a relationship model between expected quality and excited quality. The center line of the Kano diagram represents performance type issues and is the normal requirements. The expected requirements and exciting requirements are the best opportunity for competitive advantage. It is up to the company to make these requirements visible to their customer.

These two requirements will result in different customer satisfaction pattern. For the exciting requirements, customer satisfaction will be increased substantially when the requirement is able to meet expectations. Customer satisfaction will not be seriously affected, even if these requirements do not meet customers' expectations. For the expected requirement, on the other hand, customer satisfaction will be severely affected when the requirement do not meet customers' expectations. These expected requirements will not cause much increase in customer satisfaction, even if they do meet expectations.

2 (a) (ii)

Z-axis insertion of parts, also known as the top-down approach, refers to insertion along the line of sight. The assembly will be faster and more precise if the assembler has a good view of the larger assembly as well as the parts to be added. The assembly process can also be improved by decreasing ambiguity in part orientation and by making parts with self-locating features.

Lower symmetry value can decrease manipulation and assembly time by decreasing the possibilities for incorrect orientation. To the extreme, a part that can be assembled in only one orientation will decrease ambiguity. However, handling time might increase as the assembler needs to be adept in spatial recognition.

2 (b)

Part	α-angle(^{o})	β-angle
2	360^o	0^o
3	360^o	90^o
4	360^o	90^o
5	360^o	360^o
6	180^o	180^o
7	360^o	0^o
8	360^o	180^o

Assumption:

1. Parts 2, 3, 4, 5, and 8 are inserted in the same direction, which is along the length of the screw.
2. Parts 6 and 7 are inserted in the same direction, which is along the length of the bolt.
3. The lamp assembly power connector can be assembled in any direction.
4. The spacer's holes and both sides of its faces are identical.

2 (c)

To begin with, one should obtain the best information about the product. Then, the product should be disassembled. An identification number is assigned to each item as it is removed, starting from 1. Manual handling and insertion worksheet or tables should be used to determine the exact assembly time.

Then, the product is to be reassembled back in decreasing order of identification number. The worksheet can then be completed. Using the worksheet, the Design Efficiency (D) can be calculated with the formula of "3*NM/TM", where NM is the theoretical minimum number of parts, and TM is the total time for assembly of the current design.

Design Efficiency = $\frac{3 \times NM}{TM}$

Finally, the improvement ratio (D2/D1) can be determined, if necessary.

Before redesign,
NM = 8; TM = 65 sec
Design Efficiency = D2/D1 = 0.369

After redesign,
NM = 8; TM = 22.5 sec
Design Efficiency = 1.067

The redesign has an improvement ratio of 2.89.

Question 3

3 (a)

The DFM Principle 1 on Minimize Number of parts and DFM Principle 4 on Multi-functional parts was used to simplify the design. Some redundant parts were combined to reduce the number of parts. Besides, several parts were simplified by combining several functions into one function. The modified design contains three major parts, namely the main frame, guide pin, and actuation lever.

The cutting tool in the original design was deemed redundant and was combined with the main frame. Besides that, the flexible property of the main frame enables it to be a replacement for the original spring. Hence, the main frame holds the functions of cutting and act as a spring.

The actuation lever has an additional protrusion which acts as a pivot to imitate the motion created by the original cam.

The guide pin in the modified design combines the original guide rail and rollers, and act as a part to hold the entire assembly together.

3 (b)

Part 1 is needed in large quantity and no additional machining is required. Part 2 is needed in moderate quantity and n additional machining is required. Part 3 is needed in limited quantity and high precision drilling is required. Part 4 is needed in small quantity and machining needs to be done.

Since part 1 and 2 have the same dimensions, can be made of same materials, and both having large quantity, they can be cast using the same mould. Hence, Part 1 and 2 belong to the same group.

Part 3 belongs to its own group. Since only 2 units are needed annually, this part can be machined separately and drilled.

Part 4 also belongs to its own group. This part can be machined separately and milled.

3 (c)

Voice of Customer can be solicited via three methods, namely one-on-one customer interview, focus groups and in-context customer visit.

One-on-one customer interviews are useful because the interviewer can effectively probe for details from the interviewee. Focus groups method tends to be more productive because the participants may build upon one another's comments and result in many creative ideas. In-context customer visits allow team members to observe how customers use existing products or perform existing functions, which will eventually lead to dramatically improved understanding of what the customer really needs.

3 (d)

Row Weight = importance rating * sales point weightage * improvement ratio

	Customer Requirement	Row Weight
1	Requirement 1	21.6
2	Requirement 2	10.5
3	Requirement 3	16.2
4	Requirement 4	8
5	Requirement 5	24.3

I will choose Requirement 2 for the next stage of deployment. Currently, requirement 2 has a Customer Competitive Evaluation (CCE) of 3, while our main competitor only has a CCE of 3.7. It is relatively simple for us to surpass them in this requirement. Besides, the 4.5 customer satisfaction goal is relatively easy to achieve from the current CCE of 3.

Requirement 1 and 3 are not chosen because they have a relatively low CCE of 2, making it difficult to achieve the CCE goal of 4.5. Furthermore, we are quite capable in these two requirements when compared to our competitor, lacking behind by less than 0.2 in CCE.

Requirement 5 is not chosen because we perform better than our main competitor in terms of CCE. Hence, we need not pay further attention to further develop this requirement.

Requirement 4 is not chosen because we are currently ahead of our main competitor in terms of CCE and we are already at our CCE goal of 4.5. Hence, no further effort needs to be put in for this requirement.

Question 4

4 (a) (i)

Environmental Management System (EMS) performs evaluation at organizational level for environmental-related issues. EMS uses Environmental Auditing and Environmental Performance Evaluation to perform its tasks.

Environmental Auditing evaluates a company's environmental controls in both input and output. It also recommends remedial measures to minimize the impact of the company's operations on the environment.

Environmental Performance Evaluation measures the impact of a business on the environment. These impacts can be measured from the quantity and content of its air emissions, liquid effluents and solid wastes.

4 (a) (ii)

a) The objectives of the Singapore Green Label is to promote public awareness of the impact on the environment of consumer products during manufacture, use and disposal. Besides, it aims to subtly compel businesses to be more environmentally-conscious.

b) mercury-free Batteries, biodegradable Detergents, energy-saving Lamps.

4 (b)

(i) Carbon Footprint

Carbon footprint is the total set of greenhouse gas (GHG) emissions caused by an organization, event or product. For simplicity of calculation, it is often expressed in terms of the amount of carbon dioxide, or its equivalent of other GHGs. For example, one unit of methane gas can be expressed as 23 units of carbon dioxide.

In order to measure carbon footprint, you should first determine your company's quantity and emission type, either direct or indirect. Then, you should select the appropriate carbon emission Factor based on standards set by your country. Carbon footprint can then be expressed as the sum of the product of the quantity of emission and the respective emission factor.

Carbon footprint of a company can be biased because it only takes into account of the GHG produced to measure the environmental impact of the company. However, it is not capable of capturing the side effects that an industry can bring. For example, a timber-producing company can have a relatively low carbon footprint, although it causes global warming by removing precious trees.

(ii) Carbon Credit

Carbon credit is part of a tradable permit scheme which provides a way to limit company's emission. One carbon credit provides the owner the right to emit one tonne of carbon dioxide.

According to the Kyoto protocol, every country will be given an upper limit of carbon credit, which directly limits the amount of carbon dioxide that all industries in that country can produce.

Carbon credit can be awarded via carbon offset, whereby a company invests in projects that reduce the emission of greenhouse gases in the short or long term, such as the field of renewable energy. Besides that, a company can also develop and adopt environmentally-friendly practices to earn carbon credits.

(iii) Carbon Trading

Carbon trading is carried out by a market based mechanism which allows countries or companies to purchase and sell carbon credit. In this market, companies with low carbon footprint will opt to sell their additional carbon credit to increase revenue. A company with high carbon footprint will purchase the additional carbon credits that it needs. The market price for a carbon credit fluctuates, according to the trading market.

The carbon trading provides additional revenue to companies which end up with extra carbon credit allowances. Hence, companies will have the incentives to adopt environmentally-friendly practices and reduce emission. Besides, companies which have difficulty reducing their emission can have alternative methods of acquiring more carbon credits. Ultimately, while companies trade carbon credits, the carbon dioxide emission for the country can still be maintained below the permissible level.

On the downside, some companies need not reduce their emission for a few years due to over-allocation of carbon credit. On top of that, power generation companies might generate lesser power so as not to exceed their emission quota. Hence, supply for power decreases giving rise to price hike. Currently, a comprehensive and structured international framework for carbon credit trade is absent.

Question 5

5 (a) (i)

The four phases of Life Cycle Assessment(LCA) are:

a. Define goal and scope
b. Inventory analysis
c. Impact assessment
d. Interpretation

5 (a) (ii)

a. Source and age of data
b. Geographical correlation – location of data collection (localization) and the size of the area covered.
c. Time correlation
d. Method of data collection – measurement methods, measurement errors, number of measurements, presence of intrinsic data quality fluctuations
e. Completeness – whether the data is representative, seasonal fluctuations, whether there is sufficient number of data points.
f. Validation of data – whether it was done by an expert (ISO mandates that all data must be validated.

5 (a) (iii)

One of the Proxy Indicator that is often used is Embodied Energy. Embodied Energy (EE) takes into account the amount of energy consumed during manufacture. EE provides a good representation for energy-consuming products which require precious resources to manufacture, such as building and packaging materials. However, there are some products which do not require much energy during its fabrication, but which nonetheless impact the environment negatively, such as natural products (e.g. timber).

5 (b) (i)

- Material chosen should be environmentally-compatible and recyclable. A material compatibility matrix (or table) can be used to determine the degree to which two materials can be processed together.
- Similar materials and colors should be used for ease of sorting. Dissimilar materials should be identified by marking them.
- Volume of plastic and composite materials used should be reduced.
- If product is to be shredded before recycling, un-shreddable material should be avoided.
- To minimize contamination, secondary finishing processes such as painting, plating and coating should be avoided.

5 (b) (ii)

- The types of plastics used in a product should be standardized.
- All plastics should be marked according to standards.
- Components made of different recyclable materials should be easily separable, or compatible materials which can be recycled as a mixture should be used.
- Painting processes should be minimized or eliminated to prevent staining.
- Waste during manufacture should be minimized.