

12 Pages

1. Please give the information requested in the boxes below.
2. Enter your name in the space provided to the right, fold over and seal down (using the label provided) to hide your name.
3. The answers must be legibly written. The Examiners can either ignore illegible script or have it typed and the expense of typing charged to the candidate.
4. Write your answers in ink.
5. Begin each answer on a fresh page. Do all rough work in the answer book and cross it through.
6. No part of this book is to be torn out; it must be handed in complete.
7. If more books than one are used, fasten them together using the tags available from the invigilator(s).
8. **Every book must be handed in. In no circumstances may answer books, used or unused, be taken out of the examination venue.**

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1	Student Number	1809799
2	Title of Examination Paper	ENG MANGT ELEC
3	Module Code	SGEE6004
4	Date and Time of Examination	05/05/2023 09:30
5	Examination Venue	CSG
6	Seat Number	
7	Number of Answer Books handed in	

List the numbers of the questions you have attempted	Office Use
1	20
2	20
4	18
Total	58

Mark confirmed as
58 (KC)

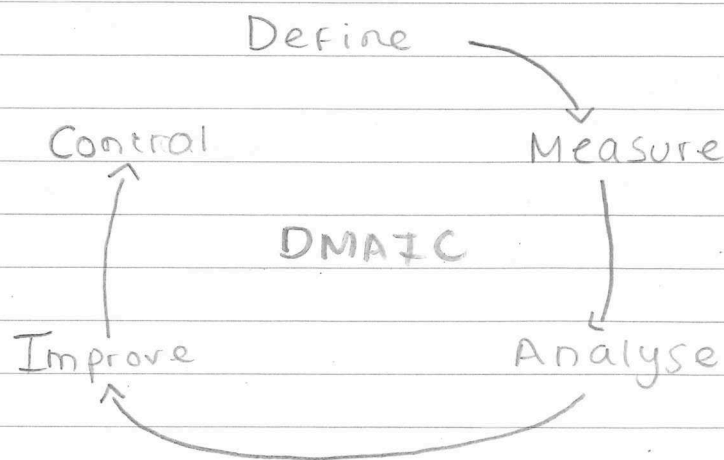
Q1

Six Sigma was developed by Motorola in the 1980s as a process improvement model for manufacturing processes. Many large companies including General Electric adopted the philosophy into their manufacturing plants, crediting it to savings in excess of \$12 Billion dollars from the 1990s. ✓

Six Sigma is a data driven, statistical analysis methodology which aims to increase process efficiency, reducing the defect rate to an almost perfect quality level of 3.4 ✓ per million opportunities (Defects). Other aims of Six Sigma is to increase productivity, profits, Overall Equipment Efficiency (OEE), whilst reducing waste in the form of time, process waste (inefficient steps, material wasted). ✓

Six Sigma aims to prevent defects, instead of detecting defects.

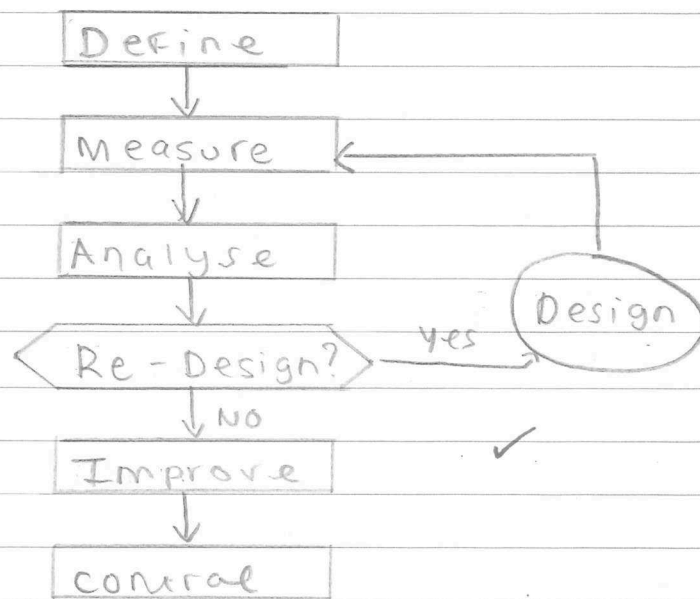
Six Sigma utilizes the DMAIC cycle as a process improvement tool. Following the 5 DMAIC Phases.



3

The First stage of the DMAIC cycle is defining the product requirements. This includes the requirements of the customer, i.e. what is the problem and what is the required output for the system, process requirements are also outlined to determine the systems inputs, outputs, controls and resources. The Second stage is the Measure phase, As much data as possible on the current process is gathered, including key metrics such as OEE, TAKT time, tolerance bands etc. From this the process capability is defined. The Analyse stage compares the current process data to the requirements of the improvement project, this is useful to set a benchmark for the extent of the improvements, problems are prioritised, and root cause analysis is undertaken to determine the problems underlying issues, tools such as "5 whys" and "Ishikawa Cause and effect" diagrams are implemented, whilst "pareto analysis" will outline the frequency of the problems, Further prioritising the required improvements. Improve is the Fourth stage, in this stage an improvement program is implemented to combat the issues uncovered in the previous stages, it is essential that the project team is involved in discussions on the solution, once a solution is decided "Failure Modes and effect analysis" should be undertaken to determine if the solution will fail, and if so how. The opinions of the project team is vital at this stage, engaging with others from different backgrounds will aid the project development, the experience of other team members is useful during design stages.

The Final Stage of the DMAIC cycle is "Control". The Improvement method must be controlled to ensure the process does not revert to old ways. Quality management Systems like ISO 9000 will ensure this. Statistical Process control should be regularly undertaken to measure that the Improvement is producing an output in line with requirements. ✓



Within the Special purpose machinery Sector, an adaptation of DMAIC is implemented geared towards new designs instead of improving processes. This is DMADV, the first three phases are identical to DMAIC. Phase 4 is the Design stage where the engineering team hold internal reviews, external reviews and customer reviews, again using Failure modes and effect analysis (FMEA) to outline any potential failure points for the machine.

The design will be "Validated" or "Verified" depending on the scale, this could be prototyping or Full functional design testing towards a test plan. ✓

Six Sigma is an efficient methodology for improvements. It enforces "Management by Fact", allowing for ~~data~~ decisions to be made based upon facts, instead of assumptions. Six Sigma is also advantageous, due to its ability to determine process improvements on highest value. It offers clear logical implementation, with key performance indicators on data, allowing employees to be upskilled through statistical analysis training.

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However, Six Sigma has its downsides. It is hard to implement in smaller companies due to the expenses and resources required. A Black belt is required to oversee the project, with multiple Green belts running aspects of the improvement projects, requiring skilled large teams. Many companies are hesitant in providing training due to rival companies poaching employees. It is not always the company fault, some employees do not agree with the methodologies strict process, believing it removes the freedom of individual problem solving. * 1

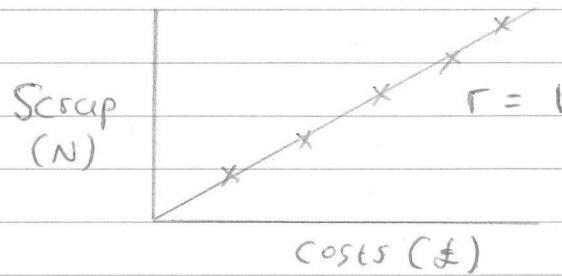
3

Overall, Six Sigma is a useful tool but it requires extensive teams, all with the same idea and resources to face the project.

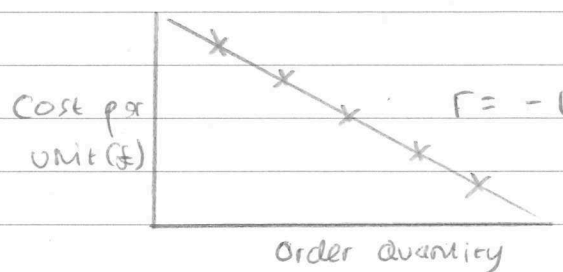
* 1, Six Sigma also may cloud judgement, ignoring simpler measures to improve the process e.g. 5S

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Q2/A) Direct correlation occurs in scatter graphs where the variables follow the same sense. For example, if a machine is operating out of tolerance, scrap parts are produced. This increases company costs due to wasted time and material. Also known as positive correlation. ✓



Inverse direct correlation is where the scatter graph variables follow opposing senses, as order quantities increase, the cost per unit decreases. ✓



When plotting a scatter chart, a line of best fit is plotted which introduces errors / inaccuracy. Utilising regression analysis, the straight line law ($y = mx + c$) is used to measure the average movements of the individual scatter points toward a line of best fit, allowing for predictions to be made based on existing data. ✓

26)

X	Y	XY	X ²	Y ²
3	6.1	18.3	9	37.21
4	7	28	16	49.0
5	7.9	39.5	25	62.41
6	8.8	52.8	36	77.44
7	9.4	65.8	49	88.36
8	9.9	79.2	64	98.01
9	11.0	99.0	81	121.0
10	11.4	114.0	100	129.96
11	12.2	134.2	121	148.84
12	13.1	157.2	144	171.61

$$\sum x = 75$$

$$\sum y = 96.8$$

$$\sum xy = 788$$

$$\sum x^2 = 645$$

$$\sum y^2 = 983.84$$

$$N = 10$$

$$m = \frac{\sum xy - \frac{\sum x \sum y}{N}}{\sum x^2 - \frac{(\sum x)^2}{N}} = \frac{788 - \frac{(75 \times 96.8)}{10}}{645 - \frac{(75)^2}{10}}$$

$$m = \frac{788 - 726}{645 - 562.5} = 0.75 \checkmark$$

$$c = \frac{(\sum x)(\sum xy) - (\sum y)(\sum x^2)}{(\sum x)^2 - N(\sum x^2)} = \frac{(75)(788) - (96.8)(645)}{(75)^2 - 10(645)}$$

$$c = \frac{59100 - 62436}{5625 - 6450} = 4.04 \checkmark$$

Therefore, $y = mx + c$

$$y = 0.75x + 4.04 \checkmark$$

Nozzle Angle

A strand diameter of 15°, will have a likely strand diameter of :

$$y = 0.75(15) + 4.04 = 15.29 \text{ } \phi \text{ mm} \checkmark$$

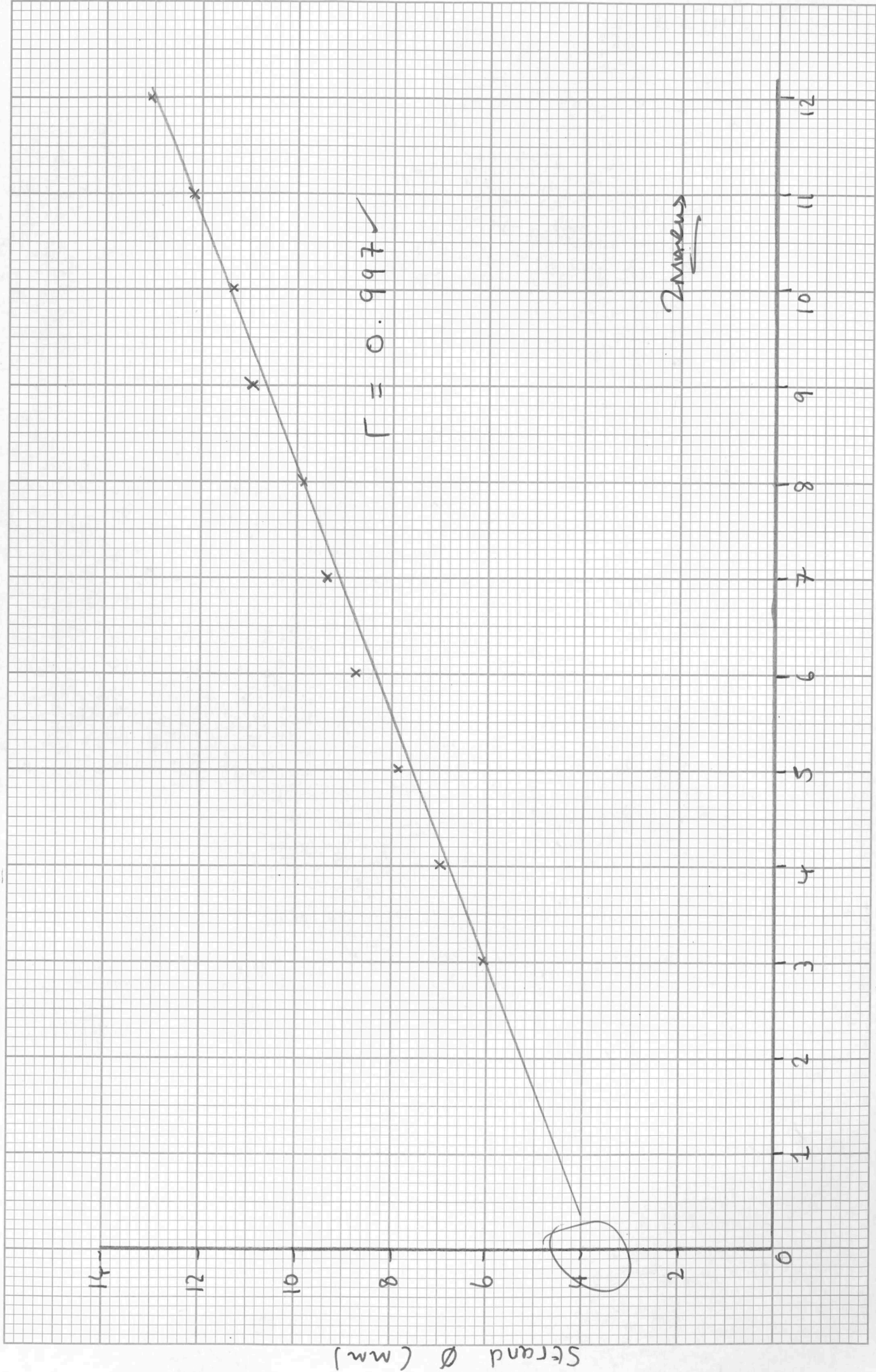
$$r = \frac{\sum xy - \frac{(\sum x)(\sum y)}{N}}{\sqrt{\left[\sum x^2 - \frac{(\sum x)^2}{N} \right] \left[\sum y^2 - \frac{(\sum y)^2}{N} \right]}}$$

$$r = \frac{788 - \frac{(75)(96.8)}{10}}{\sqrt{\left[645 - \frac{(75)^2}{10} \right] \left[983.84 - \frac{(96.8)^2}{10} \right]}}$$

$$r = \frac{788 - 726}{\sqrt{82.5 \times 46.816}} = 0.997625 \quad \checkmark$$

$$r^2 = 0.997625^2 = 0.995 \quad \checkmark$$

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Nozzle Angle (°)

4) Total Productive Maintenance (TPM) is a production philosophy which believes that everyone within a manufacturing facility should automatically take part in maintenance as part of autonomous teams, to work towards zero breakdowns, zero accidents and zero down time. It should not be just the maintenance department undertaking maintenance, but the skills of all employees should be used to maintain equipment reliability.

Benefits of implementing a TPM program is increased reliability, production time, increased safety, less accidents whilst conforming to safety standards.

EBS Automation employ single minute exchange of die (SMED) philosophy into the design of machines which run multiple variants requiring tool changes. SMED principles maximises external elements (Things that can be done to help changeover when the machine is running), and minimises internal elements (Things that cannot be changed over when running the machine), following the principles tool changes often take less than 10 minutes, increasing the availability factor of the machines overall equipment efficiency, maximising production time. Detailed instructions are displayed on the Human Machine Interface (HMI) to give clear instruction on tool change procedures, using quick disconnect fittings and fasteners where possible to reduce changeover time.

Radio Frequency Identification (RFID) is implemented on tooling to incorporate "poka yoke" principles to speed up changeovers and prevent machines from crashing due to wrong tooling. New technologies such as IO-link are incorporated to aid production and maintenance tasks. Sensors use port qualifier information (PQI) to self-diagnose any issues before breakdowns occur, including impairment, overcurrent and range issues.

TPM is introduced to monitor the "mean time before failure" of equipment. MTBF is a key metric in determining the efficiency of a TPM program.

TPM transforms a company's maintenance approach from reactive to preventive. Reactive breakdowns vastly reduce productivity and efficiency, only performing maintenance when an asset is broken down, negatively impacting production schedules. Preventive maintenance should follow manufacturers' guidelines to systematically maintain all systems components, during planned time where inspections can be made to monitor equipment standards, allowing for components to be replaced before breakdowns occur.

The aim of TPM is to control the MTBF of an asset, systematically increase the MTBF through planned maintenance, develop a structured TPM program and monitor the MTBF scientifically through data analysis to improve performance.

TPM is an important philosophy implemented when designing machines. EBS Automation produce a comprehensive machine manual detailing daily, ~~month~~ weekly, monthly and annual checks to be made to ensure the MTBF is as high as possible. Including critical spares lists to ensure customers have the required equipment to change if required, maximising production efficiency, eliminating a reactive maintenance approach.

To maximise efficiency, manufacturers must develop efficient TPM plans in conjunction with maintenance and production. Enforce a TPM regime for all employees across the plant, preventing downtime due to breakdowns, and more importantly reduced accidents.

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