Question 1

(a) Give three applications for parallel surfaces in engineering. [3 marks]

(b) Explain how a parallel curve can be calculated, given the base curve. [2 marks]

(c) A 2-D space curve is defined by

\[ r(s) = 3s^2i + 2s^3j \]

If the curve is to be machined with a 10 mm diameter ball ended milling cutter, calculate the required x and y components of the velocity as a function of time. Assume a cutting speed of 40 m/min and a feed rate of 2mm/sec. [20 marks]

Question 2

(a) What is flexible about a Flexible Manufacturing System? [5 marks]

(b) What is the ultimate economic batch size for an FMS and how can this help to implement an efficient JIT system? [5 marks]

(c) What, essentially, is the difference between production pushed and sales led manufacturing? What are their relative advantages and disadvantages? [4 marks]

(d) Give three different kinds of manufacturing systems and explain the relative advantages and disadvantages. [6 marks]

(e) Explain how Volume, Variety and Value Added help to determine which kind of manufacturing system to be used. Your answer should make reference to (d) above. [5 marks]

Question 3

(a) Describe two different types of fuel cell, one a high temperature (SOFC) and the other a low temperature (PEM). Which type of fuel cell is considered best suited to vehicle use? Which cell uses internal reforming and which cell uses external reforming? [15 marks]

(b) What are the advantages and disadvantages of using Hydrogen as a fuel for vehicles? How could Hydrogen be produced in a sustainable, environmentally friendly manner? [5 marks]

(c) Assume a fuel cell with external reforming is used to drive a vehicle. What extra equipment is needed for the complete system? How does this extra equipment change the power/weight and power/volume ratios? [5 marks]
Question 4

(a) Write down the parametric equation of
i) straight line,
ii) bi-linear surface  

(b) What is the condition that a bi-linear surface is FLAT?  

(c) Write down the equation of a double curved B-Spline and explain each of the terms. Sketch a double curved surface which forms a surface patch.

(d) Define a Ruled Surface.

(e) Explain how a spline can be used to model an aerofoil cross section. How can this be extended to model a complete aircraft wing?

Question 5

(a) What is Reverse Engineering? Your answer should give some examples of its use and explain how the QFD ‘House of Quality’ is used in Reverse Engineering. Also explain how the House of Quality relates the voice of the customer to cost drivers. Be sure to identify the ‘customers’ accurately.

(b) What is Benchmarking? How does Benchmarking help in the product placement and marketing of a particular design of automobile? How does Benchmarking help identify a Unique Selling Point? Give some examples of automobile design used as unique selling points.

(c) What is Robust Engineering Design? What is the main technique used in Robust Engineering Design? Give some examples of how the technique can improve the quality of the manufacturing process.
Question 6

Fig Q6 shows a standard urban driving cycle for assessing vehicle fuel consumption. Table Q6 gives numerical values.

(a) Assume the mass of the vehicle is 1500 kg, estimate how much kinetic energy could be recovered by regenerative braking, using an electrical motor/generator.  

[5 marks]

(b) Estimate the total time in which all this recoverable energy must be stored.  

[2 marks]

(c) Give three different methods of storing electrical/mechanical energy, which could be used for a hybrid automobile. List their advantages and disadvantages and explain which is the most suitable.  

[15 marks]

(d) Why are there so few hybrid vehicles on the road, as compared with conventional IC engines and transmission systems?  

[3 marks]

Fig Q6

Maximum speed = 32 km/h
Acceleration time, \( t_a \) = 19s
Cruise time, \( t_{cr} \) = 15s
Coast time, \( t_{co} \) = 4s
Brake time, \( t_{br} \) = 5s
Idle time, \( t_i \) = 25s
Total time = 72s
Approx number of cycles per mile = 4-5

Table Q6

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External Examiner: Professor M. Imregun