ME6315 ADVANCED METROLOGY AND COMPUTER AIDED INSPECTION FINAL TEST 2005

Max. Marks: 30+20=50 **Time: 3 Hours**

Use separate answer sheets for Part A and B

Part A

1. a) A cone has a base diameter of (50+/-2.23)mm and height of (100+/-2.23)mm. The uncertainty values are expanded uncertainties with 95% confidence and ten degrees of freedom. Assume that both variables are normally distributed. Determine the volume of the cone and its combined standard uncertainty if the diameter and height measurements are known to be correlated with a correlation coefficient of 0.8.
   b) The capacitance of a capacitor is known to be between 40 and 50mF. Determine the standard uncertainty of the measurement if it is i) uniformly distributed ii) triangularly distributed, between the two values.
   c) The specification for the outer diameter of an engine valve is 5+0.05mm. This is an important dimensional parameter for the satisfactory functioning of an engine. On measuring the diameter of a valve, it was found to be (5.045+/-0.008)mm. Is the valve acceptable if the guard band is a) 100% b) 50%.

   (6+3+3 marks)

2. a) The temperature in a metrology laboratory varies from 15°C to 30°C over the course of 12hrs and back to 15°C in another 12hrs. Express the temperature in the form of a simple Fourier series.
   b) Explain the effect of varying the sample time period while digitally sampling an analog signal.
   c) A 0-20V, 4bit successive approximation A/D converter is used to measure an input voltage of 8.9V. Determine the binary representation and its analog approximation of the input signal.
   d) What are the purposes of signal conditioning in Data Acquisition Systems?

   (3+3+3+3 marks)

3. a) Illustrate and explain what is structured lighting.
   b) Explain fractal compression and wavelet compression.
   c) Apply the horizontal line detection mask $\begin{matrix} -1 & -1 & -1 \\ +2 & +2 & +2 \\ -1 & -1 & -1 \end{matrix}$ to the image matrix $\begin{matrix} 2 & 3 & 4 & 3 \\ 6 & 6 & 6 & 3 \\ 2 & 3 & 4 & 2 \\ 3 & 2 & 3 & 2 \end{matrix}$, limiting excursions of the mask to avoid edge effects. Do not bother about intensities going out of range.
   d) Sketch the shape of the object represented by the 4-directional crack chain code 222221111003330003. How can you make this code independent of the starting position?

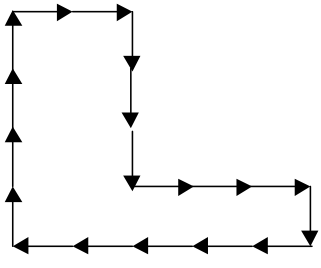
   (3+3+3+3 marks)

SOLUTIONS TO NUMERICAL PROBLEMS

1. a) $v = \frac{\pi d^2 h}{12} = 65450 mm^3$, $c_d = \frac{\pi dh}{6} = 2618 mm^2$, $c_h = \frac{\pi d^2}{12} = 654.5 mm^2$, $u_v = 3166 mm^3$
   b) i) 2.887mF, ii) 2.04mF
   c) Since dimension is important, use stringent acceptance. With 100% guard band, the effective tolerance zone becomes 5.008~5.042, hence rejection. With 50% guard band, the effective tolerance becomes 5.004~5.046, hence acceptable.

2. a) $Temp = 22.5 + 7.5 * \sin \pi \left(\frac{t-6}{12} \right)$

   c) 0111 = 8.75V

4. c) $\begin{matrix} 18 & 11 \\ -8 & -4 \end{matrix}$

   d)