First Semester Examination
2023/2024 Academic Session

February 2024

# EMT 211 – Engineering Probability & Statistics
***(Kebarangkalian dan Statistik Kejuruteraan)***

Duration: 3 hours
*(Masa: 3 Jam)*

Please check that this examination paper consists of SIX (6) pages of printed material before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi ENAM (6) muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]*

**Instructions**: Answer ALL **FOUR (4)** questions.

*[**Arahan**: Jawab **EMPAT (4)** soalan]*

...2/-

1. (a) The Quality Control personnel of a manufacturing company has proven 0.99 chance of correctly identifying defective items but a 0.005 chance of incorrectly classifying a good item as defective. The company has evidence that its line produces 0.01 of nonconforming items.

   (i) Determine the probability that an item selected for inspection is classified as defective.

   (ii) If an item selected at random is classified as non-defective, calculate the probability that it is actually good.

   **(60 marks)**

   (b) (i) Prove $(A \cup B) - B = A - (A \cap B)$ using the set algebra.

   (ii) Use Venn diagram to confirm the set operations in Q1 (b) (i).

   **(40 marks)**

2. (a) A jam producer claims that the mean weight of strawberry jam in a jar is 230g. A random sample of 8 jars is selected and the weight of strawberry jam in each jar is determined. The results (in g) are

   220 228 232 219 221 223 230 229

   Assuming that the weight of the strawberry jam in a jar is normally distributed, at 5% level of significance, perform hypothesis test on the jam producer's claim.

   **(40 marks)**

   (b) The midterm grades on the statistics exam, graded on a scale of 0 to 100, were:

   62 64 65 65 68 70 72 72 74 75 75 75 76 78 78

   81 83 83 84 85 87 88 92 95 98 98 100 100 740

   (i) Construct a stem plot for this data, using only the values in the range 0–100.

   (ii) Describe the distribution of the statistics exam scores.

   **(20 marks)**

...3/-

(c) Given the defect rate of spectacles production is 6.3%. Assume that the spectacle defects are independent of one another and the manufacturing line will be producing another 2000 pairs of spectacles.

(i) Calculate the expected number of defective spectacles produced.

(ii) Compute the standard deviation of the defective spectacles.

(iii) Determine the probability that the manufacturer will produce less than 135 defects.

**(40 marks)**

3. (a) The relationship between shear strength of material (in kN/mm) and spot weld diameter (in mm) was presented as in Table 3 (a).

Table 3 (a)

| **Weld diameter *(mm)*** | **Shear strength of material *(kN/mm)*** |
|---|---|
| 4.2 | 51 |
| 4.4 | 54 |
| 4.6 | 69 |
| 4.8 | 81 |
| 5.0 | 75 |
| 5.2 | 79 |
| 5.4 | 89 |
| 5.6 | 101 |
| 5.8 | 98 |
| 6.0 | 102 |

(i) Create the regression formulation of the data.

**(15 marks)**

(ii) Determine the correlation coefficient of the two variables and verify the correlation value is 0.9606 at 0.01 confidence interval.

**(15 marks)**

(iii) Evaluate **TWO (2)** inferences that one could deduce from the value determined in Q3 (a) (ii).

**(20 marks)**

(b) A structural engineer studied the statistical analysis of vibration modes of a suspension bridge using accelerometers. The study was conducted for 18 vertical modes of damping and their frequencies for those modes as shown in Table 3 (b).

...4/-

Table 3 (b)

| Damping ratio | Frequency (Hz) | Damping ratio | Frequency (Hz) |
|---|---|---|---|
| 0.3 | 2.72 | 0.5 | 1.53 |
| 0.3 | 2.84 | 0.6 | 0.77 |
| 0.3 | 3.77 | 0.6 | 1.26 |
| 0.4 | 2.07 | 0.6 | 1.66 |
| 0.4 | 2.20 | 0.7 | 0.89 |
| 0.4 | 2.34 | 0.7 | 1.00 |
| 0.4 | 2.61 | 0.7 | 0.66 |
| 0.5 | 1.80 | 0.8 | 1.13 |
| 0.5 | 1.93 | 0.8 | 0.37 |

(i) Compute the least-square line for the data in Table 3 (b). Verify that the linear model is appropriate.

**(15 marks)**

(ii) Using the most appropriate model, compare the frequency for the vibration with the damping ratios of 0.1 and 1.0 respectively.

**(20 marks)**

(iii) Determine the standard deviation of the data and explain the results.

**(15 marks)**

...5/-

4. (a) In a laboratory test of a new engine design, the emission rate (in mg/s of oxides of nitrogen, $NO_x$) was measured as a function of engine speed (in km/h), engine torque (in Nm) and total horsepower (in BHP). The MINITAB output is presented for the following models:

$$\text{NOx} = \beta_o + \beta_1 speed + \beta_2 torque + \beta_3 BHP + \varepsilon \quad \text{(Eq. I)}$$

$$\text{NOx} = \beta_o + \beta_1 speed + \beta_2 BHP + \varepsilon \quad \text{(Eq. II)}$$

The regression equation is
$NO_x$ = -302 + 0.366 speed -0.211 torque +0.16 BHP

| Predictor | Coeff | SE Coeff | T | p |
|---|---|---|---|---|
| Constant | -301.8 | 347.3 | -0.87 | 0.392 |
| Speed | 0.3660 | 0.2257 | 1.62 | 0.116 |
| Torque | -0.2106 | 0.8884 | -0.24 | 0.814 |
| BHP | 0.164 | 2.889 | 0.06 | 0.955 |

S=68.31 R-sq=51.6% R-sq(adj)=46.4%

The regression equation is
$NO_x$ = -380 + 0.416 speed -0.520 BHP

| Predictor | Coeff | SE Coeff | T | p |
|---|---|---|---|---|
| Constant | -380.1 | 104.8 | -3.63 | 0.001 |
| Speed | 0.41641 | 0.07510 | 5.54 | 0.000 |
| BHP | -0.5198 | 0.1980 | -2.63 | 0.014 |

S=67.19 R-sq=51.5% R-sq(adj)=48.2%

(i) From the ANOVA data above, compare whether the two equations (Eq. I) and (Eq. II) are collinear and which one is the most significant.

**(15 marks)**

(ii) Determine **TWO (2)** main errors that might occur during measuring the data.

**(15 marks)**

(iii) Deduce the conclusion that you may get from the mix-mode method used.

**(20 marks)**

...6/-

(b) As a consultant engineer in a company, you are assigned to carry out an experiment on the performance of a new engine for S90. The experiment was conducted to analyze the independent variables A (brand), B (blade type), and C (fuel used) on 2 dependent results (torque and speed).

(i) Based on Taguchi method and using Orthogonal arrays, state the type of orthogonal array choosen and the hypothesis of the experiment.

**(30 marks)**

(ii) Evaluate your design of the new engine using design of experiment (DOE) method.

**(20 marks)**

**- oooOOOooo -**