

MCE380
First Midterm Exam - Spring 2009
Dr. Richter

11 questions, duration: 90 minutes

Mark your answers in the answer sheet with pencil.

Open books and notes. No laptop computers, cell phones, PDAs, etc.

1: The Reynolds number is defined as

$$\text{Re} = \frac{\rho V D}{\mu}$$

where ρ is density, V is velocity, D is diameter and μ is dynamic viscosity. The Prandtl number is defined as

$$\text{Pr} = \frac{c_p \mu}{\kappa}$$

where κ is thermal conductivity and c_p is specific heat. Knowing that $\text{Re}^x \text{Pr}^{1/3}$ is dimensionless, the value of x is:

- a) 2
- b) 1/2
- c) 1/3
- d) -1/3
- e) None of the above.

Questions 2 thru 6 apply to the following set of data corresponding to a sampling of the Gaussian random variable x : {90.13, 89.13, 88.13, 88.13, 91.13, 93.13, 88.13, 89.13, 86.13, 87.1300}

2:

- a) The mean is between the mode and the median
- b) Estimates of the population mean and standard deviation are, respectively, 89.03 and 2.0248
- c) An additional sample extracted from the population has a probability of 1/22 of being more than 3 standard deviations away from the mean.
- d) b) and c) are true.
- e) None of the above.

3:

- a) [88.1899, 89.8701] is an 80% confidence interval for the mean
- b) [88.1444, 89.9156] is an 80% confidence interval for the mean
- c) [87.8563, 90.2037] is a 99.9% confidence interval for the mean
- d) a) and c) are true.
- e) None of the above.

4: We need to determine the accuracy in the calculation of the derived quantity $f(x) = x^3/1000 - \sin(x)$. Suppose an 80% confidence interval is used to determine the accuracy Δx . The value closest to the root-mean-square uncertainty Δf is

- a) 29
- b) 23

- c) 25
- d) 21
- e) 18

5: Application of Chauvenet's criterion would result in:

- a) Elimination of three points
- b) Elimination of two points
- c) Elimination of $x = 93.13$
- d) Elimination of no points.
- e) None of the above.

6: Suppose $[87.5816, a]$ is a $p\%$ confidence interval

- a) $p = 95\%$
- b) $t = 2.262$
- c) $a = 90.4784$
- d) All of the above
- e) None of the above.

7: Select the true statement:

- a) Accuracy, as opposed to precision, is a preferable characteristic for a measurement instrument.
- b) Calibration improves accuracy.
- c) Calibration improves precision.
- d) Lack of precision is associated with randomness.
- e) More than one of the above statements is true.

8: The following voltage-distance data was generated by a transducer:

Distance (mm)	Voltage (V)
-2	-12
-1	-7.5
0	-3
1	1.5
2	7
3	13
4	19
5	28

- a) The transducer is linear throughout its range.
- b) The sensitivity is 4.5 V/mm for a range of distances.
- c) The sensitivity is -4.5 V/mm for a range of distances.
- d) The sensitivity increases in the high range of distances.
- e) b) and d) are correct.

9: Which statements are correct about a Gaussian population?

- a) Roughly 68% of the data is found within a standard deviation from the mean.
- b) Roughly 16% of the data is less than the mean minus one standard deviation.
- c) Roughly 25% of the data is higher than the mean plus 0.6745 times the standard deviation
- d) All of the above
- e) None of the above

An instrument uses the ideal gas equation to measure temperature:

$$PV = mRT$$

Suppose the nominal pressure and mass are $P = 2$ MPa and $m = 0.002$ kg. The gas constant is accurately known to be $R = 287.06$ J/kg/K, and the volume is also known accurately to be $V = 1 \times 10^{-4}$ m³. The pressure is measured with an accuracy of ± 10 kPa and the mass with an accuracy of $\pm 1 \times 10^{-5}$ kg.

10: The worst-case temperature deviation is closest to:

- a) 5.5 K
- b) 3.5 K
- c) 2.5 K
- d) 1.5 K
- e) 2 K

11: Now suppose that the mass is accurately known to be the nominal value, but the volume is measured with an accuracy of $\pm 1 \times 10^{-6}$ m³. The rms temperature interval is closest to

- a) [344.5, 352]
- b) [342, 354]
- c) [347, 349]
- d) [343, 353.5]
- e) [338.5, 358]