

2009 MEC603 Advanced Metrology and Computer Aided Inspection – Test 1

Max. Marks: 20

Approved tables are permitted

Time: 50 minutes

1. Define calibration and traceability. Discuss the connection between them.

(3 marks)

2. A thermocouple was calibrated with results as below. Determine the sensitivity of the thermocouple and its 90% expanded uncertainty. The reference junction was maintained at 20°C.

Sl No	1	2	3	4	5	6
Temperature °C	40	90	140	40	90	140
Voltage mV	1.06	3.80	6.53	1.12	3.77	6.56

(5 marks)

3. The tensile stress that can be applied normal to a closed crack is given by Griffith as $\sigma = \sqrt{\frac{4E\gamma}{\pi a}}$,

where E is the modulus of elasticity, γ the specific surface energy and a the length of the crack.

Measurements of a crack on a glass plate gave the results: 7.5, 8, 7.5, 6.5, and 7.5 μm . From a handbook, the specific surface energy of glass was obtained as 0.3 J/m² with a statement that "the error will not exceed 0.02 J/m²". The modulus of elasticity is known to be (70+/-5) GPa with 95% confidence. Determine the maximum stress that can be applied to the glass plate and its standard uncertainty.

(7 marks)

4. The annual income of a firm for the current year is expected to be Rs15 lakhs with a standard uncertainty of Rs3 lakhs. The annual expenses are estimated as Rs12 lakhs with a standard uncertainty of Rs2 lakhs. Past data of a sample of the annual income and sales are as follows:

Year	2000	2001	2002	2003	2004
Income	20	10	18	15	12
Expense	16	9	13	10	11

Estimate the profit for the current year and its standard uncertainty.

(6 marks)

SOLUTION TO NUMERICAL PROBLEMS:

2.

Temperature oC	Voltage mV	ycap	ei			
40	1.06	1.079167	-0.01917		42.4	
90	3.8	3.806667	-0.00667		342	
140	6.53	6.534167	-0.00417		914.2	
40	1.12	1.079167	0.040833		44.8	
90	3.77	3.806667	-0.03667		339.3	
140	6.56	6.534167	0.025833		918.4	
Intercept	-1.102833333	SSE	0.004108	Sumxy	2601.1	22.84
Slope	0.05455	MSE	0.001027	CSxy	545.5	
		u(y)	0.032048			
sumsqx	58600					
sumx	540					
CSxx	10000					
u(Slope)	0.000320481					
tinv	2.131846486					
U(Slope)	0.000683217		U+	0.055233	U-	0.053867

3.

	7.5, 8, 7.5, 6.5, and 7.5									
	7.50E-06	8.00E-06	7.50E-06	6.50E-06	7.50E-06					
		Unc	Dist	std unc	a+	a-	E+	E-	Gamm a+	Gamma-
a	0.0000074	5.48E-07	Type A	2.45E-07	7.64495E-06	7.16E-06	7.4E-06	7.4E-06	7.4E-06	7.4E-06
E	7.00E+10	5.00E+09	Normal	2.55E+09	7.00E+10	7.00E+10	7.26E+10	6.74E+10	7.00E+10	7.00E+10
Gama	0.3	0.02	Uniform	0.011547	0.3	0.3	0.3	0.3	0.311547	0.288453
Sigma	60110293.27				59139467.69	61130555	61195796	59004824	61256194	58942119
	60.11029327				-995543.6788		1095486		1157037	
					1878811.546					
					1.878811546	MPa				

$$c_E = \sqrt{\frac{\gamma}{\pi a E}} = 0.000429359; c_\gamma = \sqrt{\frac{E}{\pi a \gamma}} = 100183822.1; c_a = \sqrt{\frac{-E\gamma}{\pi a^3}} = -4.06151E+12$$

Contributions

cE	0.000429359	1095304
cGama	100183822.1	1156823
ca	-4.06151E+12	-994862

4.

Income	Expense	x-xbar	y-ybar	prod	
20	16	5	4.2	21	
10	9	-5	-2.8	14	
18	13	3	1.2	3.6	
15	10	0	-1.8	0	
12	11	-3	-0.8	2.4	
15	11.8	4.123106	2.774887	10.25	
			r	0.895888666	0.895889
u(Income)		3	9		
u(Expense)		2	4		
		-10.7507			
	sumsq	2.249336			
	uc	1.499779			