2007 Advanced Metrology and Computer Aided Inspection – Test 1

Max. Marks: 20 Time: 50 minutes

1. Differentiate between Type A and Type B evaluation of uncertainty.

(2 marks)

2. The results of a beam bending test are as follows:

Sl No	Strain X 10^{-3}	Stress (MPa)
1	0.2	20
2	0.4	45
3	0.6	65
4	0.8	90
5	1.0	110
6	1.2	130
7	1.4	150

Estimate the modulus of elasticity of the material and its expanded uncertainty using regression, assuming strain to have negligible uncertainty.

(8 marks)

3. The energy consumed by an electric iron is determined by measuring its resistance, no load voltage and time of operation. Seven readings of resistance were 80, 82, 78, 83, 81, 79, and 80Ω. The no load voltage was (230+/-2)V (99% expanded). The time was measured as 30min using a digital watch with least count 1min. Estimate the 95% expanded uncertainty of energy consumed in Joules. Consider the effect of change in resistance due to heating and drop in voltage due to loading by taking a correlation coefficient of -0.4 between resistance and voltage.

(10 marks)

SOLUTION TO NUMERICAL PROBLEMS:

2. Modulus of elasticity is given by the slope of the regression model.

Strain	Stress	ypred	res
0.2	20	22.32143	-2.321429
0.4	45	43.92857	1.071429
0.6	65	65.53571	-0.535714
0.8	90	87.14286	2.857143
1	110	108.75	1.25
1.2	130	130.3571	-0.357143
1.4	150	151.9643	-1.964286
Int	0.714286	SSE	20.53571
Slope	108.0357	MSE	4.107143

u(y) = 2.026608708
Sum(xsq) = 5.6
(Sumx)sq = 31.36
CSxx = 1.12
u(Slope) = 1.914965231
t(95%, 5) = 2.570577635
U(Slope) = (103.1131475, 112.9582811)GPa

3.

R=80.42857, s=1.718249

$$E = \frac{V^2 t}{R} = \frac{230*230*1800}{80.42857} = 1183908$$

$$u_V = \frac{2}{2.576} = 0.776398\,,\ c_V = \frac{2Vt}{R} = \frac{2*230*1800}{80.42857} = 10294.85\,,\ u_V(E) = 7992.8952$$

$$u_t = \frac{0.5*60}{\sqrt{3}} = 17.32051\,,\ c_t = \frac{V^2}{R} = \frac{230*230}{80.42857} = 657.7265\,,\ u_t(E) = 11392.16$$

$$u_R = \frac{1.718249}{\sqrt{7}} = 0.649437\,,\ c_R = \frac{-V^2 t}{R^2} = \frac{-230*230*1800}{80.42857*80.42857} = -14720\,,\ u_R(E) = -9559.71$$

$$u_{VR}(E) = 2*-0.4*7992.895*-9559.71 = 61131784$$

$$u(E) = 18606\,,\ U = (1220896,\ 1146919)\ \text{J}(95\%)$$

		u	V+	V-	R+	R-	t+	t-
V	230	0.776398	230.7764	229.2236	230	230	230	230
R	80.42857	0.649437	80.42857	80.42857	81.07801	79.77913	80.42857	80.428571
t	1800	17.32051	1800	1800	1800	1800	1817.321	1782.6795
E	1183908	16.07651	1191914	1175928	1174425	1193545	1195300	1172515.5

uV(E)	7992.895	uR(E)	-9560.332	ut(E)	11392.157	r	-0.4
	63886374		91399943		129781231	uVR(E)	61131784
u(E)	18606.43						
dof	86.0819						
t(95,86)	1.987933						
1220896	1146919						