2008 MEC603 Advanced Metrology and Computer Aided Inspection – Test 1

Max. Marks: 20 Time: 50 minutes

1. A slip gauge of size 25mm was measured using a micrometer repeatedly and resulted in the following readings: 25.08, 25.12, 25.09, 25.13, 25.11, 25.09, 25.12, and 25.11. Estimate the systematic error and random error for the first reading.

   (2 marks)

2. An LVDT based height measuring device was calibrated using slip gauges with the following results:

Sl No	Slip Gauge Input x (mm)	Device Reading y (mm)
1	10	12
2	10	11
3	20	23
4	20	22
5	30	31
6	30	32
7	40	42
8	40	43

   Determine the regression equation. Also estimate the uncertainty of the y intercept in the regression equation.

   (6marks)

3. A motor car is 50m from an electric post with uncertainty +/-0.5m(95%). A force of 5000N with uncertainty 50N (99%) is applied on the car at an angle of 30^{o} to the longitudinal axis, uniformly distributed within $+/-1^{o}$. The car moved forward and five measurements of the distance from the electric post were: 76, 77, 75, 74, and 75m. Determine the work done and its 95% expanded uncertainty, if the two distance measures have a correlation coefficient of 0.5.

   (12 marks)

SOLUTION TO NUMERICAL PROBLEMS:

1.

True value	25
Mean	25.10625
Systematic error	0.10625
Random Error	-0.02625

2.

x	y	ycap	res	x^2
10	12	11.7	0.3	100
10	11	11.7	-0.7	100
20	23	21.9	1.1	400
20	22	21.9	0.1	400
30	31	32.1	-1.1	900
30	32	32.1	-0.1	900
40	42	42.3	-0.3	1600
40	43	42.3	0.7	1600
Sumx	200			
Meanx	25			
Slope	1.02			
Intercept	1.5			
SSE	3.6			
MSE	0.6			
Sumxsq	6000			
CSxx	1000			
se(Beta0)	0.67082			
t0.95,8	2.45			
U	1.64351	[-0.14351, 3.14351]		

3.

$W=F\,(b-a)\cos\theta$; $c_F = (b-a)\cos\theta$; $c_b = -F\cos\theta$; $c_a = F\cos\theta$; $c_\theta = -F(b-a)\sin\theta$;
Convert θ to radians

		u	c	contrib	sq	dof	
F	5000	19.38	21.997045	426.2993	181731.12		
b	75.4	0.5099	-4330.127	-2207.94	4875000	4	5.941E+12
a	50	0.2551	4330.127	1104.624	1220194.7		
theta	30deg	0.0101rad	-63500	-639.8681	409431.2		
W	109985.2			u(ab)	-2438944.3		
					4247412.7		
				uc	2060.9252		1.804E+13
							3.0364049
				t0.95,4	2.78		
				U	5729.3721		[115714.6, 104255.9]

Numerical approach:

		76.00	77.00	75.00	74.00	75.00				
			F+	F-	b+	b-	a+	a-	theta+	theta-
F	5000.00	19.38	5019.38	4980.62	5000.00	5000.00	5000.00	5000.00	5000.00	5000.00
b	75.40	0.51	75.40	75.40	75.91	74.89	75.40	75.40	75.40	75.40
a	50.00	0.26	50.00	50.00	50.00	50.00	50.26	49.74	50.00	50.00
theta	30.00	0.58	30.00	30.00	30.00	30.00	30.00	30.00	30.58	29.42
W	109985		110411.53	109558.93	112193.17	107777.2	108880.60	111089.8	109339.79	110619.50
			426.30		2207.94		-1104.62		-639.86	
		uF(W)=	181731.12	ub(W)=	4875000	ua(W)=	1220194		409417.34	
			4247398.88							
			2060.92						uab(W)	-2438944.28