MEV214 Metrology and Computer Aided Inspection – Test 2, Mar2010

Max. Marks: 20 Time: 60 minutes

All questions carry 2 marks each, unless mentioned otherwise.

1. The net black body radiative heat transfer per unit area between a body at temperature T_1 K and surroundings at T_2 K is given by $Q = \sigma (T_1^4 - T_2^4)$, where σ is the Stefan Boltzmann constant 56.7 X 10^{-9} $Wm^{-2}K^{-4}$ with the error absolutely not exceeding 2 X 10^{-9} $Wm^{-2}K^{-4}$. The temperature of the body was measured as 333 K triangularly distributed between +/- 1.9 K . The temperature at the surroundings was measured at five different places with the values: 288, 290, 291, 294, 292 K. Complete the uncertainty budget table given below and determine the expanded uncertainty for the heat transfer (90%). The two temperature measurements have a correlation coefficient of 0.6, but neglect its effect on the degrees of freedom.

Quantity	Value	Expd Unc	Distribution	Std Unc	dof	Contribution
σ	56.7 X 10^{-9} $Wm^{-2}K^{-4}$					
T_1	333 K					
T_2	?	-	-			
Q						-

(10 marks)

2. The result of a measurement was obtained as 32.03678 mm with standard uncertainty 0.02442 mm. Round off the result according to the recommendations of GUM, giving reasons.

3. A cheap capacitor has a specification 100 +/- 8 pF. A sample capacitor had a measured value of (108.5 +/-1) pF (95%). Is the sample OK considering a guard-band of a) 100% b) 40%. Explain why.

4. Design a GO and NOGO plug gauge to inspect a hole of size 40+0.039 mm. Use unilateral tolerances with wear allowance.

5. The distance between two slots on an aluminium component is measured using a vernier caliper as 32.42 mm. If the measurement was carried out in a room at temperature of 32 ^{o}C, estimate the correct distance. The coefficient of thermal expansion is 16 x10^{-6} K^{-1} for steel and 23x10^{-6} K^{-1} for aluminium.

6. What is meant by Abbe offset?

7. Explain how one should wring together two thin gauge blocks.

SOLUTIONS TO NUMERICALS:

1.

T2 values	288	290	291	294	292
	Value	Exp Unc	Distrib	Std unc	dof
sigma	5.67E-08	2.00E-09	Uniform	1.15E-09	inf
T1	333	1.9	Triangular	0.775672	inf
T2	291			1	4
Q	290.6157684				

	sigma+	sigma-	T1+	T1-	T2+	T2-	
sigma	5.79E-08	5.55E-08	5.67E-08	5.67E-08	5.67E-08	5.67E-08	
T1	333	333	3.34E+02	3.32E+02	3.33E+02	3.33E+02	
T2	291	291	2.91E+02	2.91E+02	2.92E+02	2.90E+02	
Q	296.5341843	284.6974	297.1346	284.1423	284.998	296.1759	
usigma(Q)	5.918415947	uT1(Q)	6.496151	uT2(Q)	-5.58891	r	0.6
	35.02764732		42.19997		31.23592		-43.5677
	64.8958548						
uc(Q)	8.055796348						
	4211.47197						
	975.6826516						
	243.9206629						
dof	17.26574502						
dof	17						
t	1.74	1.739606					
U	14.01708565						

$c_\sigma = T_1^4 - T_2^4 = 5125498560$, $c_{T_1} = 4\sigma T_1^3 = 8.37$, $c_{T_2} = -4\sigma T_2^3 = -5.59$

2.

R	32.03678
u	0.02442
u round to	0.024
R round to	32.037

3.

USL	108		
Result	108.5		
U	1		
Stringent rejection / Relaxed acceptance			
100% gb	Modified USL	109	Accept
40% gb	Modified USL	108.4	Reject

4.

LSL	USL	Tolerance
40	40.039	0.039
GO	40.000195	40.0041
No GO	40.0351	40.039

5.

L	32.42
alpha steel	1.60E-05
alpha al	2.30E-05
T	32
L20	32.41728