Kuwait University	Course 125 Phys. Lab. I
Physics Department	Experiment 8:Thermal Expansion

Determination of the Linear Coefficient of Thermal Expansion

Objectives

- To study how to use the 0.01 mm resolusion built-in dialgauge.
- To determine the linear coefficient of thermal expansion of copper, steel and aluminum.

Equipment to be used

- Long expansion base with a built-in dialgauge and thermistor (Figure 1).
- Three metal tubes { copper, steel, and aluminum.
- Foam insulator to avoid heat loss at the thermistor connection point.
- Steam source.
- Digital ohmmeter to measure thermistor resistance.

Reference

Douglas C. Giancoli, Physics Principles with Applications, Third Edition, Chapter 13.

Theory

Most materials expand somewhat when heated through a temperature range that does not produce a change in phase. The added heat increases the average amplitude of vibration of the atoms in the material which increases the average separation between the atoms. Suppose an object of length (L) undergoes a temperature change of magnitude (ΔT). If (ΔT) is reasonably small, the change in length, (ΔL), is generally proportional to (L) and (ΔT). Stated mathematically:

$$\Delta L = \alpha L \, \Delta T \tag{1}$$

$$\alpha = \frac{\Delta L}{L \, \Delta T} \tag{2}$$

where (α) is called the **coefficient of linear expansion** for the material. For materials that are not **isotropic**, such as an asymmetric crystal for example, they can have different values of linear coeffcients (α) depending on the axis along which the expansion is measured. (α) can also vary somewhat with temperature so that the degree of expansion depends not only on the magnitude of the temperature change, but on the absolute temperature as well.

In this experiment, you will measure (α) for copper, aluminum, and steel. These metals are **isotropic** so that (α) need only to be measured along one dimension. Also, within the limits of this experiment, (α) does not vary with temperature.

Procedure

1. Measure the length (L) of the copper tube at room temperature. (L) should be measured from the inner edge of the stainless steel pin on one end, to the inner edge of the angle bracket at the other end. See Figure 1.**Record** your data in Table 2.

2. Mount the copper tube in the expansion base as shown in Figure 2. **Attach** the thermistor lug to the threaded hole in the middle of the copper

tube using a thumbscrew.

3. Place the foam insulator over the thermistor lug as shown in Figure 2 and **connect** the leads of the ohmmeter into the banana connectors labeled THERMISTOR in the center of the expansion base.

4. Measure the resistance of the thermistor (R_{rm}) at room temperature. **Record** this value in Table 2.

5. Connect the steam generator to the steam inlet of the copper tube using the black hose. **Raise** the end of the expansion base at which the steam enters the copper tube.

6. Turn the outer casing of the dial gauge to align the zero point on the scale with the long indicator needle.

7. Switch the steam generator ON. When the thermistor resistance stabilizes, **record** the resistance (R_{hot}) in Table 2. Also **record** the expansion of the tube length (ΔL) as indicated by the displacement of the indicator on the dial gauge.

8. Convert the thermistor resistance (R_{rm}) and (R_{hot}) into temperature measurements (T_{rm}) and (T_{hot}) using Table 1 at the end. **Record** yoyr results in Table 2.

9. Calculate and **record** the value of (ΔT) and ($\alpha_{\ copper}$) in Table 2.

10. Repeat the experiment for the steel and aluminum tubes.

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Conversion Table

Table 1:

Temp C^o	Resistance -	Temp C^o	Resistance -	Temp C^o	Resistance -	Temp C^o	Resistance -
1	332640	26	95447	51	32253	76	12479
2	315320	27	91126	52	30976	77	12043
3	298990	28	87022	53	29756	78	11625
4	283600	29	83124	54	28590	79	11223
5	269080	30	79422	55	27475	80	10837
6	255380	31	75903	56	26409	81	10467
7	242460	32	72560	57	25390	82	10110
8	230260	33	69380	58	24415	83	9767.2
9	218730	34	66356	59	23483	84	9437.7
10	207850	35	63480	60	22590	85	9120.8
11	197560	36	60743	61	21736	86	8816
12	187840	37	58138	62	20919	87	8522.7
13	178650	38	55658	63	20136	88	8240.6
14	169950	39	53297	64	19386	89	7969.1
15	161730	40	51028	65	18668	90	7707.7
16	153950	41	48905	66	17980	91	7456.2
17	146580	42	46863	67	17321	92	7214
18	139610	43	44917	68	16689	93	6980.6
19	133000	44	43062	69	16083	94	6755.9
20	126740	45	41292	70	15502	95	6539.4
21	120810	46	39605	71	14945	96	6330.8
22	115190	47	37995	72	14410	97	6129.8
23	109850	48	36458	73	13897	98	5936.1
24	104800	49	34991	74	13405	99	5749.3
25	100000	50	33591	75	12932	100	5569.3

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Laboratory Assignment

1. Find the percentage error for the value of (α) for copper, steel, and aluminium .

2. What are the Isotropic materials?

3. What is the relationship between the coeffcient of linear expansion and the coefficient of volume expansion?

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Worksheet for Experiment 8

	L	R_{rm}	ΔL	R_{hot}	T_{rm}	T_{hot}	ΔT
copper							
steel							
aluminium							

α_{copper} = ...

α_{steel} = ...

$\alpha_{aluminum}$ = ...

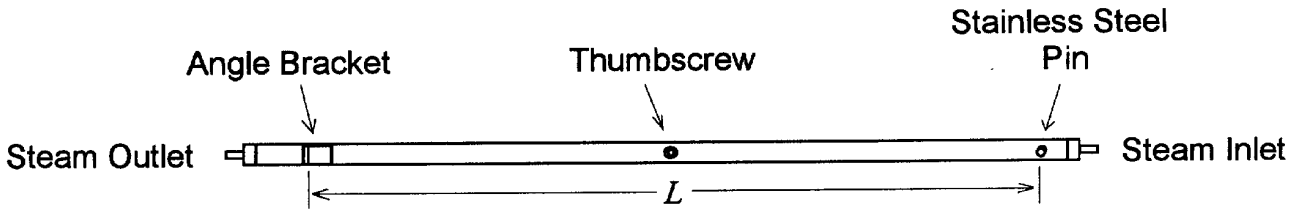


Figure 8.1: Measuring metal tube length

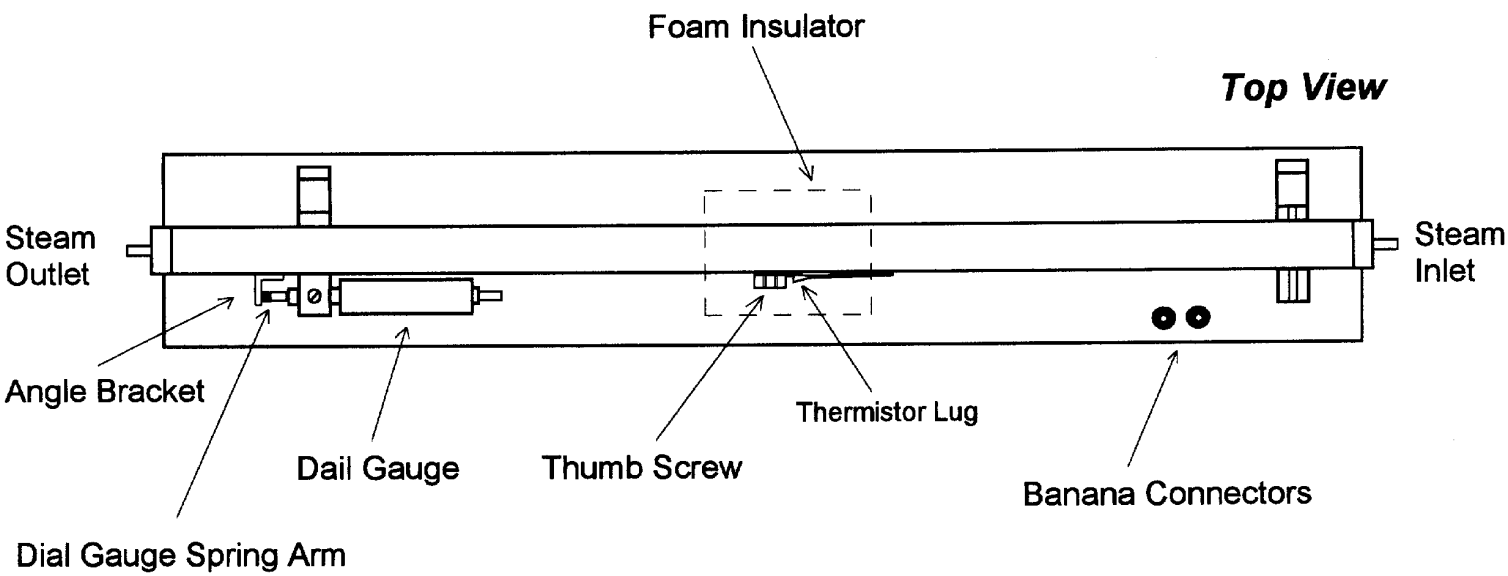
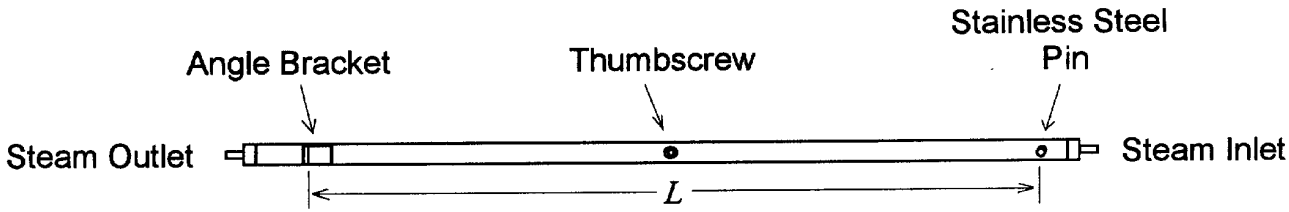


Figure 8.2 : Equipment Setup (Top View)



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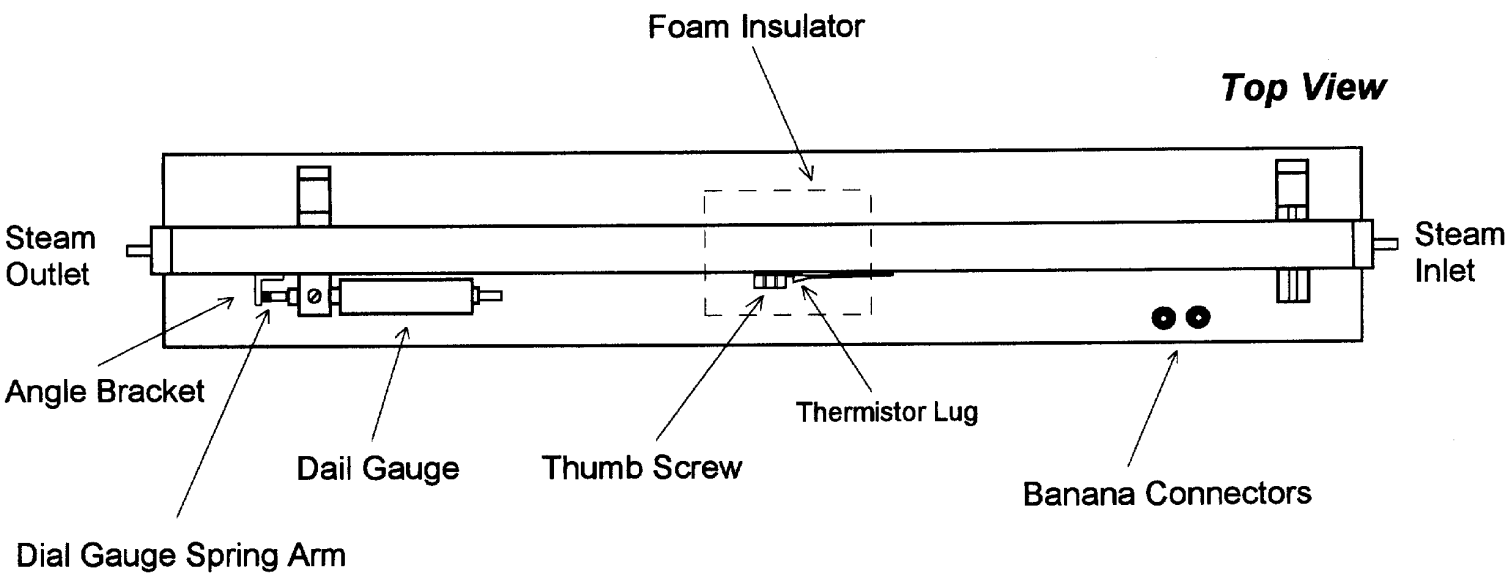

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