



Eastern Mediterranean University  
Department of Mechanical Engineering  
Laboratory Handout

**COURSE: HEAT TRANSFER (MENG 345)**

**Semester:** Spring (2019-2020)

**Name of Experiment:** Steady State Conduction Through a Uniform Wall

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Submitted by:

Student No:

Date of experiment:

Date of submission:

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**EVALUATION**

<b>Activity During Experiment &amp; Procedure</b>	<b>30 %</b>	
<b>Data , Results &amp; Graphs</b>	<b>35 %</b>	
<b>Discussion, Conclusion &amp; Answer to Questions</b>	<b>30 %</b>	
<b>Neat and tidy report writing</b>	<b>5 %</b>	
<b>Overall Mark</b>		

**Name of evaluator:**

## Objective

To measure the temperature distribution for steady-state conduction of energy through a uniform plane wall and demonstrate the effect of a change in heat flow

## Method

By measuring the change in temperature with distance, resulting from the linear conduction of heat along a simple bar at different rates of heat flow through the bar.

## Equipment required

- HT10XC Heat Transfer Service Unit

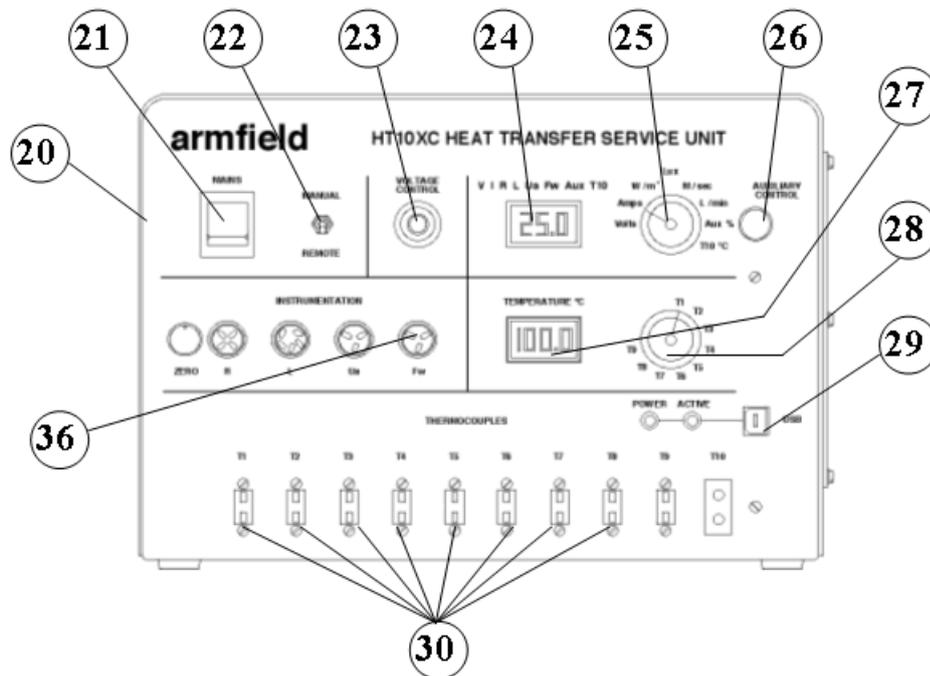


Figure 1: Front View of HT10XC

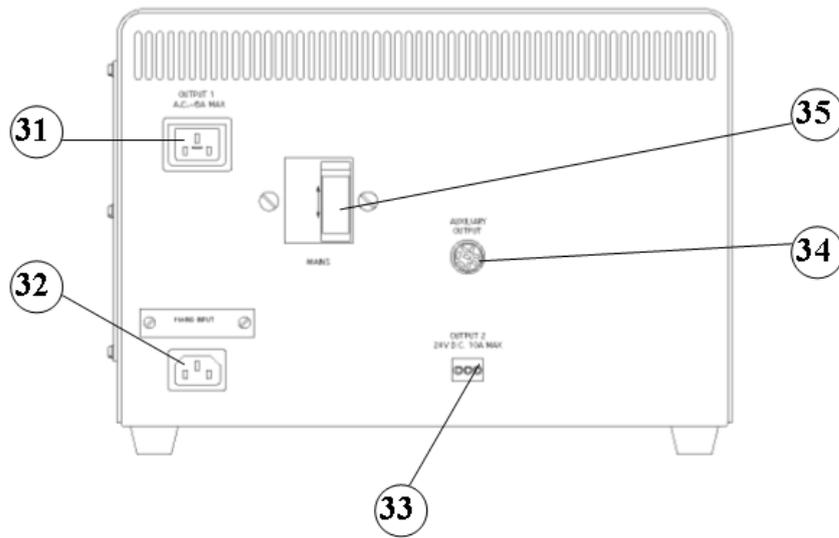


Figure 2: Rear View of HT10XC

- HT11C Computer Compatible Linear Heat Conduction Accessory (Or HT11 Linear Heat Conduction Accessory).

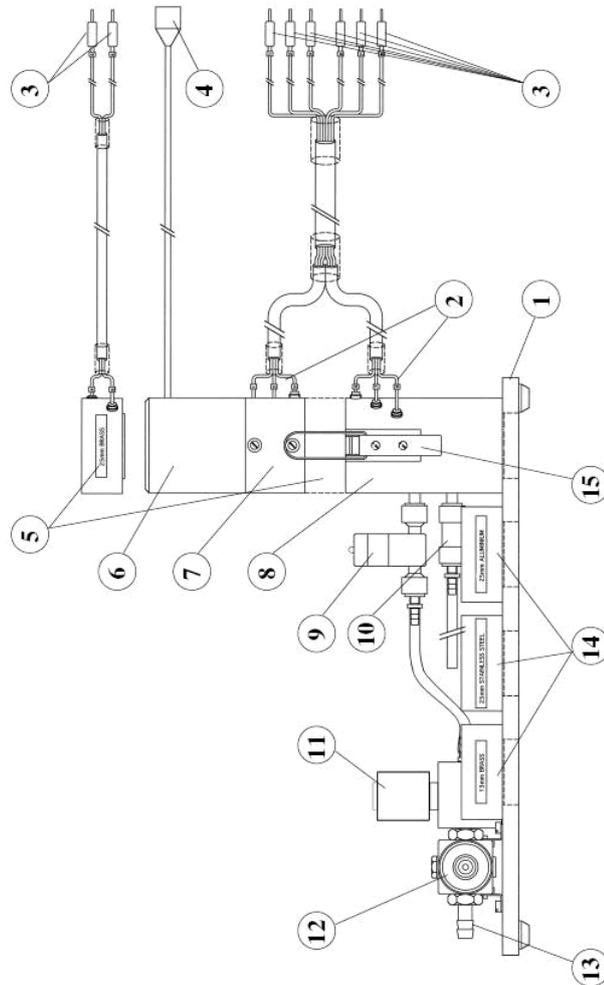


Figure 3: Side View of HT11C Computer Compatible Linear Heat Conduction Accessory

## Equipment set- up

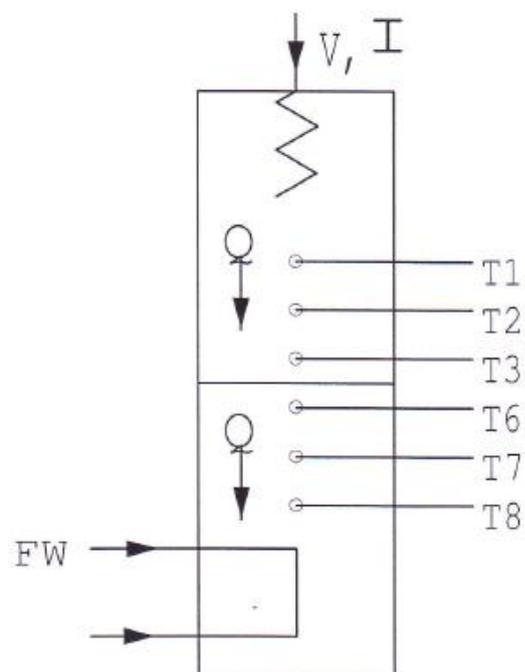
Before proceeding with the exercise, ensure that the equipment has been prepared as follows:

- Locate the HT11C Linear Heat Conduction accessory (1) alongside the HT10XC Heat Transfer Service Unit (20) on a suitable bench.
- Clamp the heated (6 and 7) and cooled (8) section of the HT11C together having lightly coated the mating faces with thermal paste (See Operation section page 3-3)
- Connect the eight thermocouples on the HT11C (3) to the appropriate sockets on the front of the service unit (30). Ensure that the labels on the thermocouple leads (T1-T8) match the labels on the sockets.

**Note:** readings from thermocouples T4 and T5 will not be used in this exercise.

- Set the VOLTAGE CONTROL potentiometer (23) on the HT10XC service unit to minimum (anticlockwise) and the selector switch to MANUAL then connect the power lead from the HT11C to the socket marked OUTPUT 2 and the rear of the service unit (33).
- Connect the cold water flow control valve (11) to the socket marked AUXILARY OUTPUT (34) on the rear of the HT10XC console.
- Connect the cold water flow rate sensor (9) to the socket marked Fw (36) on the front of the HT10XC console.
- Set the AUXILARY CONTROL knob (26) on the service unit to minimum(anticlockwise) then connect the power lead from the cold water flow control valve (11) to the AUXILARY POWER socket on the rear of the service unit (34) (Not relevant if using HT11).
- Ensure that a cold water supply is connected to the inlet of the pressure regulating valve on HT11C (13).

- Ensure that the flexible cooling water outlet tube is directed to a suitable drain.
- Ensure that the service unit is connected to an electrical supply.
- Switch on the MAINS switch on the service unit (21).
- If using a computer for remote data logging and/or operation, connect the USB socket on the HT10XC (29) to the computer using the USB cable provided, and set the selector switch on the console (22) to REMOTE. (If not using a computer, leave the selector switch set to MANUAL).
- If using a computer, start the HT11C software and select 'Exercise A'. The software includes full instructions on how to use the software and perform the exercise, and should be used in preference to this manual when undertaking the teaching exercises.

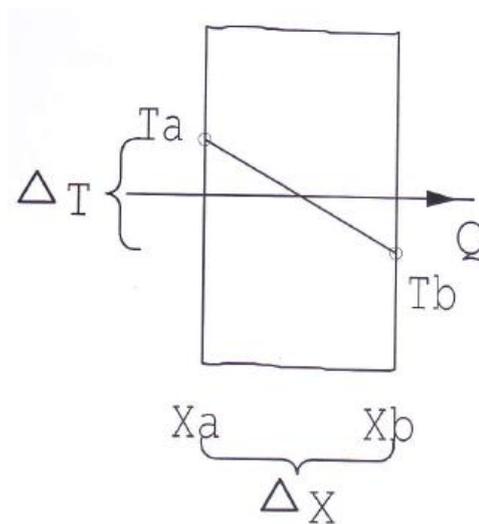


## Theory/ background

Provided that the heated and cooled sections are clamped tightly together, so that the two end faces are in good thermal contact, the two sections can be considered to be one continuous wall of uniform cross section and material.

According to Fourier's law of heat conduction:

If a plane wall of thickness ( $\Delta x$ ) and area ( $A$ ) supports a temperature difference, then the heat transfer rate per unit time ( $Q$ ) by conduction through the wall is found to be:



$$Q \propto A \frac{\Delta T}{\Delta x}$$

$$Q = C \frac{\Delta T}{\Delta x} \quad \text{Where } C \text{ is a constant which will be investigated in a later exercise.}$$

The object of this exercise is to show that for a simple plane wall where the material and cross section are constant:

$$Q \propto \frac{\Delta T}{\Delta x}$$

## Procedure

- Check the panel displays on the service console are illuminated. If the panel display do not illuminate check the RCD at the rear of the service unit: the switch should be up. If using a computer, check that the software indicates IFD OK in the bottom right hand corner of the software window.
- Turn on the cooling water and adjust the flow control valve (NOT the pressure regulator) to give approximately 1.5 litres/min. If using the software, the flow rate should be controlled using the control box on the software mimic diagram window. The flow rate may be monitored on the software screen. (If not using the software, use the selector switch (25) to display the flow rate on the panel display on the console (L/min) and AUXILIARY CONTROL knob to control the setting. If using the HT11, the cold water flow rate is controlled using the manual control valve next to the test section column).

Set the heater voltage to 9 volts:

- If using a computer, enter the voltage in the display box for the heater, or use the control box arrows.
- If using the console, adjust the voltage control potentiometer to give a reading of 9 volts on the top panel display with the selector switch set to position V.
- Allow the HT11C to stabilize. If using a computer, monitor the temperatures on the software mimic diagram screen. (If operating using the console, use the lower selector switch (28) on the console to set the console display (27) to each temperature sensor in turn).
- When the temperatures are stable, select the icon in the software to record the following: T1, T2, T3, T6, T7, T8, V I, Fw (If operating the equipment using the

console then these values should be recorded manually. Fw is not available if using the HT11 unless the optional SFT2 flow sensor is fitted).

Set the heater voltage to 12 volts.

Allow the HT11C to stabilize then repeat the above readings.

Set the heater voltage to 17 volts.

Allow the HT11C to stabilize then repeat the above readings.

Set the heater voltage to 21 volts.

Allow the HT11C to stabilize then repeat the above readings.

### **Results and Calculations**

For this exercise the raw data is tabulated under the following headings:

Heater Voltage	V	Volts
Heater Current	I	Amps
Heated section high temperature	T1	(°C)
Heated section mid temperature	T2	(°C)
Heated section low temperature	T3	(°C)
Cooled section high temperature	T6	(°C)
Cooled section high temperature	T7	(°C)
Cooled section high temperature	T8	(°C)
Cooling water flow rate	Fw	(l/min)

You should also estimate and record the experimental errors for these measurements

For this exercise the following constants are applicable:

Distance between thermocouples T1 and T3  $\Delta x_{13} = 0.03$  (m)

Distance between thermocouples T6 and T8  $\Delta x_{68} = 0.03$  (m)

Note: the distance between each thermocouple is 0.015m

The distance between thermocouple T3 and T6 and the end face is 0.0075m

For each set of readings, the derived results are tabulated under the following headings:

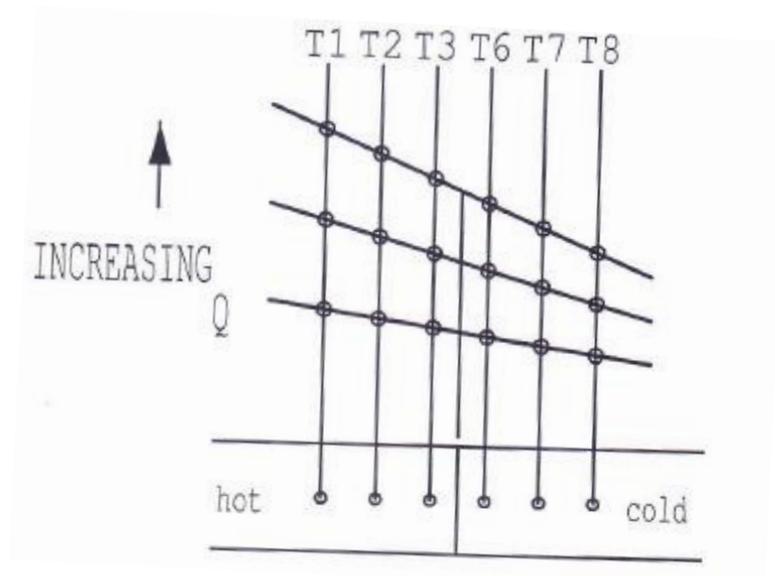
Heat flow (power to heater)	$Q = VI$
Temperature difference in heated section	$\Delta T_{\text{hot}} = T1 - T3$
Temperature difference in cooled section	$\Delta T_{\text{cold}} = T6 - T8$

Estimate the cumulative influence of the experimental errors on your calculated values for  $Q$ ,  $\Delta T$ , and  $\Delta T_{\text{cold}}$  and measure the values for  $\Delta x_{13}$  and  $\Delta x_{68}$ .

Compare the changes in temperature ( $\Delta T_{\text{cold}}$  and  $\Delta T_{\text{hot}}$ ) in the two sections at the same heat flow.

Compare the changes in temperature in the two sections at different heat flows.

Plot a graph of temperature against position along the bar and draw the best straight line through the points. Your graph should be similar to the diagram below.



Observe that each temperature profile is a straight line and that the gradient of the line increases with the increase in heat flow. Calculate the gradient of each line and show that  $\frac{Q}{\text{gradient}}$  is a constant (C).

### **Conclusion**

You have demonstrated how the heat flows through a plane wall creates a temperature difference and the temperature changes linearly with distance. For the wall of constant conductivity and constant cross sectional area the temperature gradient is directly proportional to the rate of heat flow.

Comment on the change  $\Delta T_{\text{cold}}$  and  $\Delta T_{\text{hot}}$  when the heat flows through the bar is changed. The consequences of these changes will be investigated in a later exercise.

Comment on the effects of measurement accuracy and heat loss from the equipment on your results.