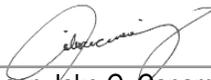
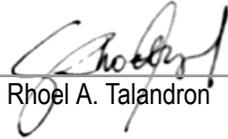


## Experiment Plan (Form CHE 3214L-1)

Prepared and submitted by:

  
Gibson Jake C. Canama

  
Monica Claire L. Delco

  
Rhoel A. Talandron

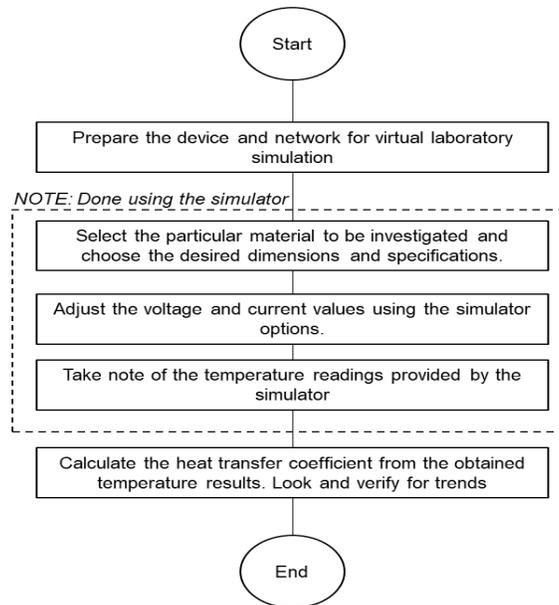
Experiment : **Heat Transfer by Convection**

### Objectives of the Experiment

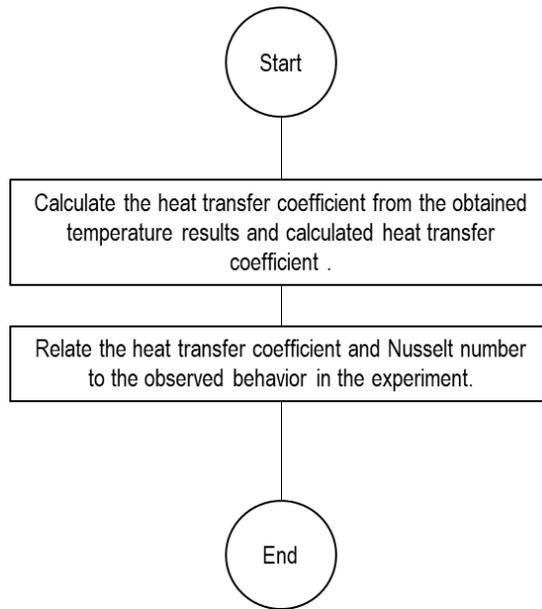
1. Determine the overall heat transfer coefficient at the surface of a given vertical metal cylinder by the natural convection method.
2. Determine the value of Nusselt number.
3. Compare the obtained experiment values to the calculated, simulator values.

### Methodological Framework

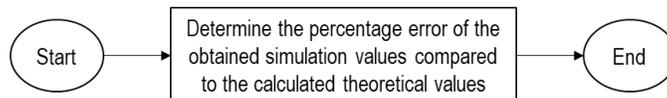
**Objective 1:** Determine the overall heat transfer coefficient at the surface of a given vertical metal cylinder by the natural convection method.



**Objective 2:** Determine the value of Nusselt number.



**Objective 3:** Compare the obtained experiment values to the calculated simulator values.



\*Selection of Material and Specified Parameters will be decided by the **instructor ONLY**.

## Materials, Measuring Apparatus & Equipment

Material	Quantity
Steel	<b>Diameter:</b> 7 cm <b>Thickness:</b> 0.10 cm <b>Length:</b> 50 cm
Iron	<b>Diameter:</b> 9 cm <b>Thickness:</b> 0.20 cm <b>Length:</b> 50 cm
Silver	<b>Diameter:</b> 8 cm <b>Thickness:</b> 0.15 cm <b>Length:</b> 52 cm
Wooden Box	STEEL: <b>Width of Wooden Box:</b> 10 cm <b>Height of Wooden Box:</b> 70 cm  IRON: <b>Width of Wooden Box:</b> 5cm <b>Height of Wooden Box:</b> 74 cm  SILVER: <b>Width of Wooden Box:</b> 8 cm <b>Height of Wooden Box:</b> 72 cm

Equipment	Specifications
Stopwatch	Measures from 0 milliseconds to as much as 99 hours, 59 minutes, 59 seconds, and 999 milliseconds <b>Resolution:</b> $\pm 1$ millisecond
Natural Convection Apparatus	Contains a thermometer, voltmeter, ammeter, and knobs for control
Thermometer	<b>Resolution:</b> $\pm 0.01$ K
Ammeter	<b>Resolution:</b> $\pm 0.02$ A Automatically adjusts with the voltage measurement
Voltmeter	<b>Resolution:</b> $\pm 10$ V Steel: 100 V Iron: 100 V Silver: 140 V

## Task Plan

Time	Task	Person Responsible
1:30-2:30	Pre-Laboratory Virtual Questioning	Canama Delco Talandron
2:30 – 2:35	Open Virtual Laboratory Link > Simulator Set-up	Canama Delco Talandron

	Selection of material from dropdown box*	(Note: Each member shall do the procedures <b>individually and simultaneously</b> )
	Determination of Wooden Box width and length*	
	Selection of cylinder diameter, length, and thickness*	
2:35 – 2:45	Selection of Apparatus Voltage through the arrows beneath the white knob* <b>Note:</b> Current will automatically adjust according to the voltage inputted in the system	Canama Delco Talandon (Note: Each member shall do the procedures <b>individually and simultaneously</b> )
	Turning on virtually the apparatus	
	Tuning the temperature indicator on the desired thermocouple reading ( $T_1$ to $T_6$ )	
	Reading of temperatures $T_1$ to $T_6$ .	
	Reading the simulator Heat transfer coefficient	
	Reading the simulator Nusselt Number	
2:45 – 3:00	Calculation (from Raw Data) the calculated transfer coefficient and Nusselt number of sample material.	Canama Delco Talandon (Note: Each member shall do the procedures <b>individually and simultaneously</b> )
3:00 – 3:35	Repeat experiment for other materials assigned ( <b>Material 2 and Material 3</b> )*.	Canama Delco Talandon (Note: Each member shall do the procedures <b>individually and simultaneously</b> )
3:35 – 4:25	Collection of raw data and Documentation Analysis and Processing of Observed Mechanisms and Data Values from the Simulator	Canama Delco Talandon
4:25 – 4:30	Final discussion	Canama Delco Talandon

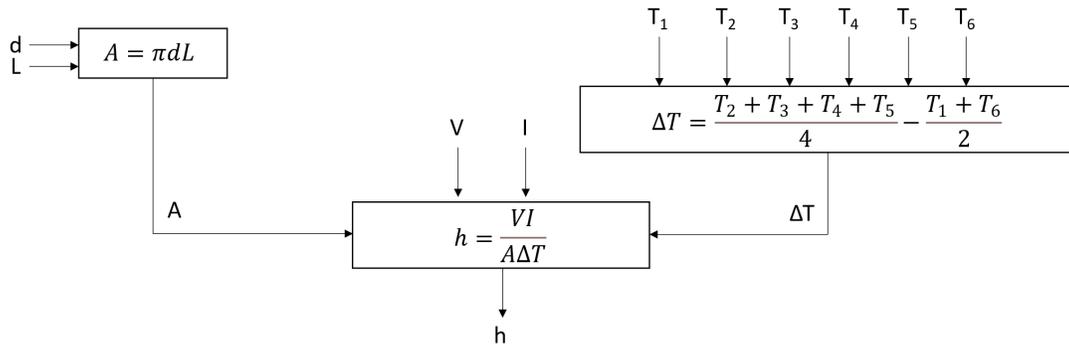
**\*Materials and Apparatus specifications will be given under the discretion of the instructor.**

### Information Flow Diagram

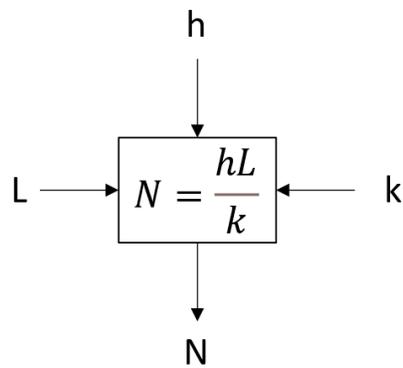
**OBJECTIVE 1: Determine the overall heat transfer coefficient at the surface of a given vertical metal cylinder by the natural convection method.**

Assumptions:

- Negligible Kinetic Energy, Potential Energy (for the entire system)
- Steady-State System



**OBJECTIVE 2: Determine the value of Nusselt number.**



**OBJECTIVE 3: Compare the obtained experiment values to the calculated, simulator values.**

$$\delta = \frac{|h_{theo} - h|}{h_{theo}} \times 100\%$$

**Legend:**

$k = \text{thermal conductivity of material} = 0.024 \frac{W}{m.K}$

$A = \text{area of heat transfer (m}^2\text{)}$

$d = \text{diameter of cylinder (cm)}$

$L = \text{length of cylinder (cm)}$

$V = \text{voltage (V)}$

$I = \text{current (A)}$

$\Delta T = \text{temperature difference between tube and air (K)}$

$T_i = \text{temperature readings of tube (K)} [i = 2, 3, 4, 5]$

$T_i = \text{temperature readings of air (K)} [i = 1, 6]$

$h = \text{convective heat transfer coefficient} \left( \frac{W}{m^2.K} \right)$

$N = \text{Nusselt number}$

$h_{theo}$  = theoretical convective heat transfer coefficient  $\left(\frac{W}{m^2 \cdot K}\right)$

$\delta$  = relative error (%)

## Raw Data Sheets

### CANAMA

#### Material 1

Material	Steel	Wooden Box	Length (m)	0.7	Cylinder	Diameter (m)	0.07	Apparatus	
			Width (m)	0.1		Length (m)	0.5	Voltage (V)	Current (A)
						Thickness (m)	0.001	100	0.2
Temperature of Tube (°C)					Temperature of Air (°C)			Simulator Data	
$T_2$	$T_3$	$T_4$	$T_5$	$T_h$	$T_1$	$T_6$	$T_c$	Heat Transfer coefficient (h)	3.40275
22.67	24.67	28.67	30.67	26.67	30	36	33	Nusselt Number (N)	99.24686

#### Material 2

Material	Iron	Wooden Box	Length (m)	0.74	Cylinder	Diameter (m)	0.09	Apparatus	
			Width (m)	0.05		Length (m)	0.5	Voltage (V)	Current (A)
						Thickness (m)	0.002	100	0.2
Temperature of Tube (°C)					Temperature of Air (°C)			Simulator Data	
$T_2$	$T_3$	$T_4$	$T_5$	$T_h$	$T_1$	$T_6$	$T_c$	Heat Transfer coefficient (h)	1.37951
48.29	50.29	54.29	56.29	52.29	30	36	33	Nusselt Number (N)	42.53503

#### Material 3

Material	Silver	Wooden Box	Length (m)	0.72	Cylinder	Diameter (m)	0.08	Apparatus	
			Width (m)	0.08		Length (m)	0.52	Voltage (V)	Current (A)
						Thickness (m)	0.0015	140	0.54
Temperature of Tube (°C)					Temperature of Air (°C)			Simulator Data	
$T_2$	$T_3$	$T_4$	$T_5$	$T_h$	$T_1$	$T_6$	$T_c$	Heat Transfer coefficient (h)	2.3698
120.34	122.34	126.34	128.34	124.34	30	36	33	Nusselt Number (N)	71.09387

#### Observation/s:

- The simulator power switch icon cannot be function and does not work when it is hovered.
- The temperature measured for air in thermocouple  $T_1$  and  $T_6$  are the same regardless of the material used or in the adjustment of other parameters of the apparatus or in the experiment.
- Among the three metals, steel has a very high heat transfer coefficient. This is then followed by silver and iron.
- At very high voltage and current, the heat flow on the system is very high.
- The direction of flow in the simulator is upward yet the heat transfer direction is at an radial position (from the inner part of the cylinder to the walls of the metal tube).

#### DOCUMENTATION:

Transfer by Natural Convection

Heat Transfer by Natural Convection

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Mon									
Material	Steel	Wooden Box	Height (m)	0.7	Diameter (m)	0.1	Cylinder	Length (m)	Thickness (m)
Temperature of Tube (°C)					Temperature of Tube (°C)				
$T_2$	$T_3$	$T_4$	$T_5$	$T_h$	$T_1$	$T_6$	$T_c$		
22.67	24.67		28.67	30.67	26.67	30	36		

Gibbs									
Material	Steel	Wooden Box	Height (m)	0.7	Diameter (m)	0.1	Cylinder	Length (m)	Thickness (m)
Temperature of Tube (°C)					Temperature of Tube (°C)				
$T_2$	$T_3$	$T_4$	$T_5$	$T_h$	$T_1$	$T_6$	$T_c$		
				#DIV/0!					



## DELCO

### Material 1

Material	Steel	Wooden Box	Length (m)	0.7	Cylinder	Diameter (m)	0.07	Apparatus	
			Width (m)	0.1		Length (m)	0.5	Voltage (V)	Current (A)
						Thickness (m)	0.001	100	0.2
Temperature of Tube (°C)					Temperature of Air (°C)			Simulator Data	
$T_2$	$T_3$	$T_4$	$T_5$	$T_h$	$T_1$	$T_6$	$T_c$	Heat Transfer coefficient (h)	3.40275
22.67	24.67	28.67	30.67	26.67	30	36	33	Nusselt Number (N)	99.24686

### Material 2

Material	Iron	Wooden Box	Length (m)	0.74	Cylinder	Diameter (m)	0.09	Apparatus	
			Width (m)	0.05		Length (m)	0.5	Voltage (V)	Current (A)
						Thickness (m)	0.002	100	0.2
Temperature of Tube (°C)					Temperature of Air (°C)			Simulator Data	
$T_2$	$T_3$	$T_4$	$T_5$	$T_h$	$T_1$	$T_6$	$T_c$	Heat Transfer coefficient (h)	1.37951
48.29	50.29	54.29	56.29	52.29	30	36	33	Nusselt Number (N)	42.53503

### Material 3

Material	Silver	Wooden Box	Length (m)	0.72	Cylinder	Diameter (m)	0.08	Apparatus	
			Width (m)	0.08		Length (m)	0.52	Voltage (V)	Current (A)
						Thickness (m)	0.0015	140	0.54
Temperature of Tube (°C)					Temperature of Air (°C)			Simulator Data	
$T_2$	$T_3$	$T_4$	$T_5$	$T_h$	$T_1$	$T_6$	$T_c$	Heat Transfer coefficient (h)	2.3698
120.34	122.34	126.34	128.34	124.34	30	36	33	Nusselt Number (N)	71.09387

**Observation/s:** Air flows up the tube. Voltmeter and ammeter readings are not displayed until the apparatus is turned on.  $T_1$  and  $T_6$  are maintained regardless of material and other settings.

## DOCUMENTATION:

### Heat Transfer by Natural Convection



AutoSave - MITCarr Raw Data - Saved - Search

File Home Insert Page Layout Formulas Data Review View Help

Calibri - 11 - A A

General

Conditional Formatting Styles Cell Styles

Font Alignment Number

Clipboard

Number

Insert - Sum - Sort & Find & Filter - Select - Analyze - Sensitivity

Delete - Format - Filter - Select - Analysis - Sensitivity

Comments

Share

Comments

Mon

Material Steel Wooden Box Height (m) 0.7 Diameter (m) 0.07 Apparatus

Width of wooden box: 10 cm

Width (m) 0.1 Length (m) 0.5 Voltage (V) 100 Current (A)

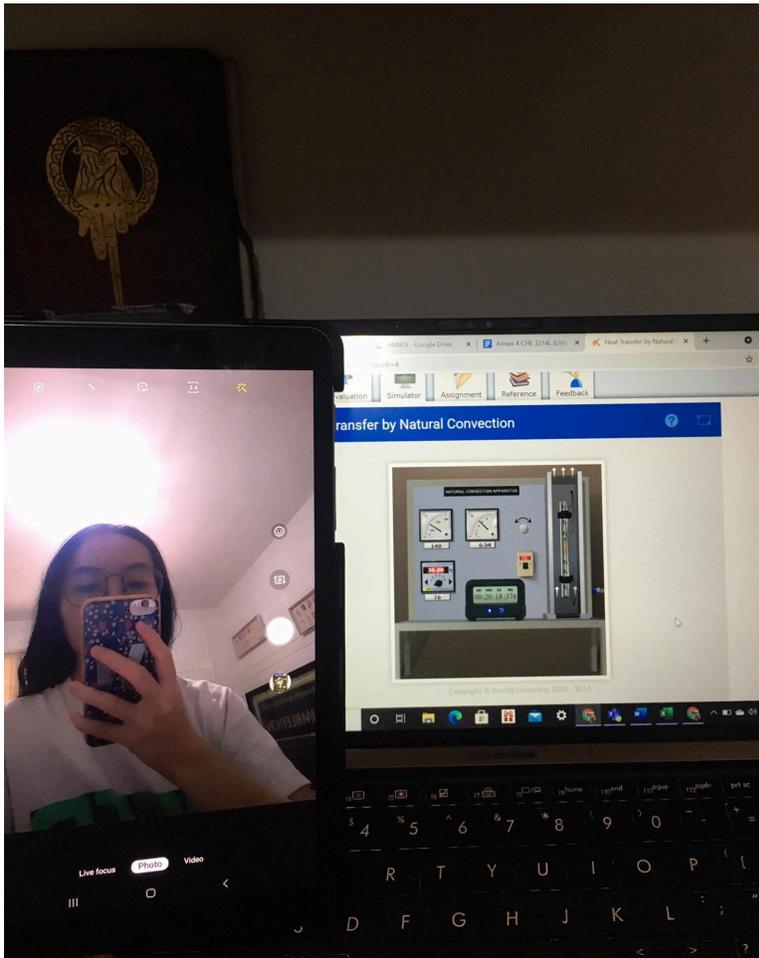
Thickness (m) 0.0015 Length (m) 0.52 Voltage (V) 140 Current (A)

0.0015

0.52

140

0.54



## TALANDRON

### Material 1

Material	STEEL	Wooden Box	Length (m)	0.7	Cylinder	Diameter (m)	0.07	Apparatus	
			Width (m)	0.1		Length (m)	0.5	Voltage (V)	Current (A)
						Thickness (m)	0.001	100	0.2
Temperature of Tube (°C)					Temperature of Air (°C)			Simulator Data	
$T_2$	$T_3$	$T_4$	$T_5$	$T_h$	$T_1$	$T_6$	$T_c$	Heat Transfer coefficient (h)	3.40275
22.67	24.67	28.67	30.67	26.67	30	36	33	Nusselt Number (N)	99.24686

### Material 2

Material	IRON	Wooden Box	Length (m)	0.74	Cylinder	Diameter (m)	0.09	Apparatus	
			Width (m)	0.05		Length (m)	0.5	Voltage (V)	Current (A)

					Thickness (m)	0.002	100	0.2	
Temperature of Tube (°C)					Temperature of Air (°C)			Simulator Data	
$T_2$	$T_3$	$T_4$	$T_5$	$T_h$	$T_1$	$T_6$	$T_c$	Heat Transfer coefficient (h)	1.37951
48.29	50.29	54.29	56.29	52.29	30	36	33	Nusselt Number (N)	42.53503

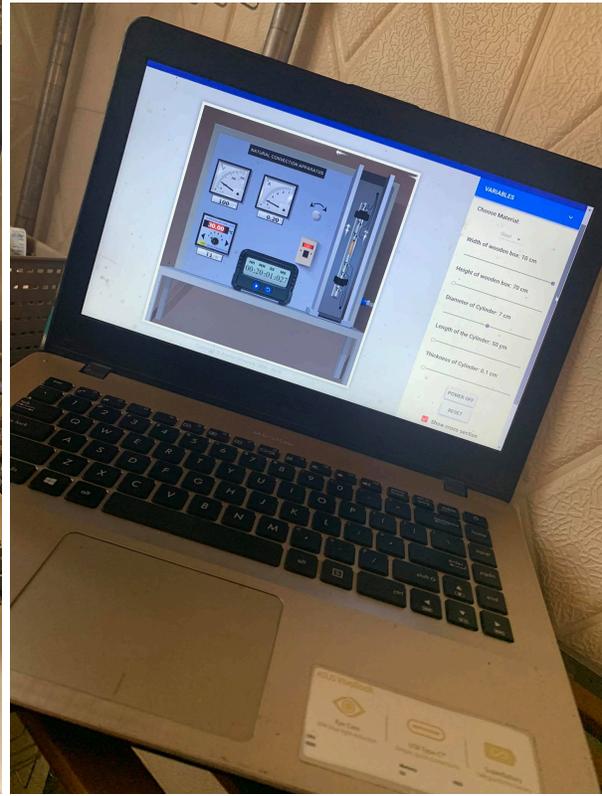
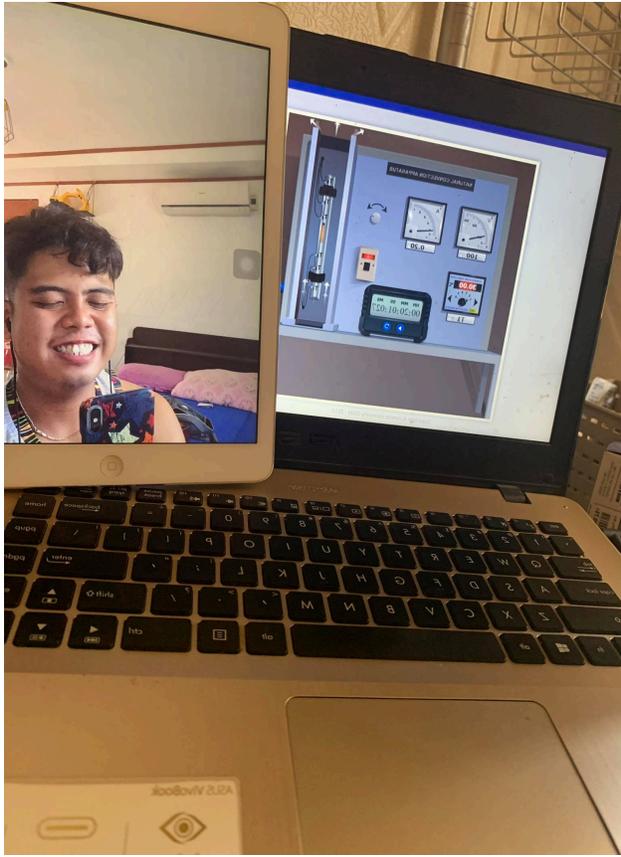
**Material 3**

Material	SILVER	Wooden Box	Length (m)	0.72	Cylinder	Diameter (m)	0.08	Apparatus	
			Width (m)	0.08		Length (m)	0.52	Voltage (V)	Current (A)
						Thickness (m)	0.0015	140	0.54
Temperature of Tube (°C)					Temperature of Air (°C)			Simulator Data	
$T_2$	$T_3$	$T_4$	$T_5$	$T_h$	$T_1$	$T_6$	$T_c$	Heat Transfer coefficient (h)	2.3698
120.34	122.34	126.34	128.34	124.34	30	36	33	Nusselt Number (N)	71.09387

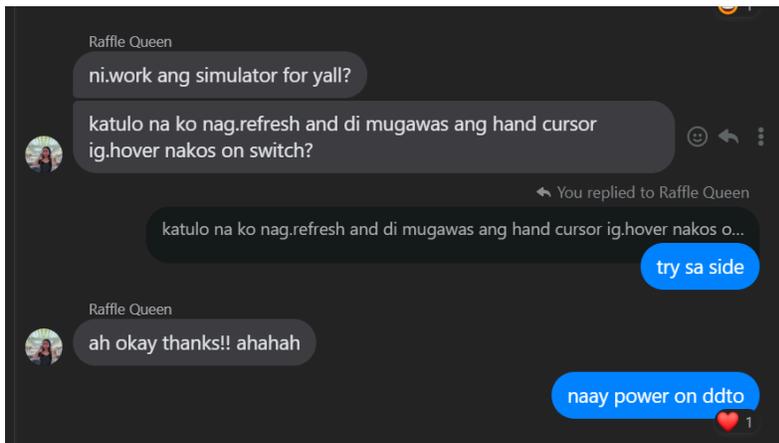
**Observation/s:**

- Sometimes, the voltage and ammeter values aren't shown despite the turning of the knob
- The temperature of air is constant regardless of material

**DOCUMENTATION:**



## TEAM DOCUMENTATION:



vection is an enhanced form of conduction, since the movement of the fluid helps carry heat transferred by conduction, so one would expect some relation between  $h$  and  $k$ . If the temperature of the cylinder is not much above that of the surrounding air, the moving fluid can be approximated as a stationary layer having some characteristic thickness  $L$ . Comparing equations (1) and (2), one immediately has the relation  $h = k/L$ . In fact, as the temperature of the cylinder increases, fluid motion increases and becomes turbulent, whereupon the fluid

Raffle Queen

couldnt figure out asa gikan sa right hand side ang naay time tho? hahaha

di siya dapat heat flow rate

kay Q along is heat

?

Raffle Queen

yea mao pud ako gi.think

so iya unit ky J/s right

ay yea ky katong Vxl