You name _________________Kyle Rex___________________________________Team # (table)_____1________

ENGR 102
Lab: Topic 5 (individual)
Canvas and ZyBook
100%

This is an individual assignment, use individual header.

Deliverables:

There are two deliverables for this individual assignment. Please submit the following files to **Canvas and zyBooks:**

- `boiling_curve_planning.pdf`
- `boiling_curve.py`

Activity #1: Planning a program – individual {60%) Submit on Canvas

In this individual assignment, you should follow a similar strategy to the one pursued for your team assignment. Note: in comparison to the team program, there are far fewer conditions and necessary test cases. However, there is more computation, including practice interpolating data (remember the topic 2 labs?). You may want to review the process for interpolation posted in Module 2 on Canvas, and see the note below the graph on the next page.

Create a Python program that will calculate the surface heat flux for water at 1 atm for a given excess temperature. You will need to create a simplified model for the relationship between heat flux and excess temperature, based on the graph on the next page (from Wikipedia where you can learn more about boiling: https://en.wikipedia.org/wiki/Nucleate_boiling). The boiling curve is important in several engineering disciplines. It informs us what boiling regime is occurring, which then helps us to determine the heat transfer coefficient, as well as physically what is going on. Different fluids have different boiling curves, however they all have a similar shape.

For this part of the assignment, put together a document you will use to plan your program. You will submit a PDF of this document titled boiling_curve_planning.pdf. Do this **before** you start to code.

First, examine the boiling curve. The curve starts out with a linear region for free convection, where boiling has not started (points A to B). The onset of nucleate boiling (B) starts at 5 °C of excess temperature and continues roughly linearly until the critical heat flux (C) is reached. This portion of the curve is the nucleate boiling regime, which is what we typically see when boiling water for cooking pasta. There is a negative roughly linear trend from the critical heat flux down to the Leidenfrost point (D) which is the transition region, followed by an upward nearly linear film region (D to E). You do **NOT** need to understand the physics behind the boiling curve for this assignment.

Come up with a simplified, purely linear model of the stress-strain curve. In other words, approximate the curve by a series of **straight-line segments** between the labeled points. You should approximate the graph using 4 linear segments. The lines should begin at point A and end at point E. Using more lines would give a more accurate representation, but would be more work in coding; for this assignment, you do not need to be precise, and should use just 4 segments along with **the points given below the graph**.

Lab: Topic 5 (individual) ENGR 102 Section 516 **Lab 5b**

Date: __9/28/22___ **DUE DATE: 9/28/22**

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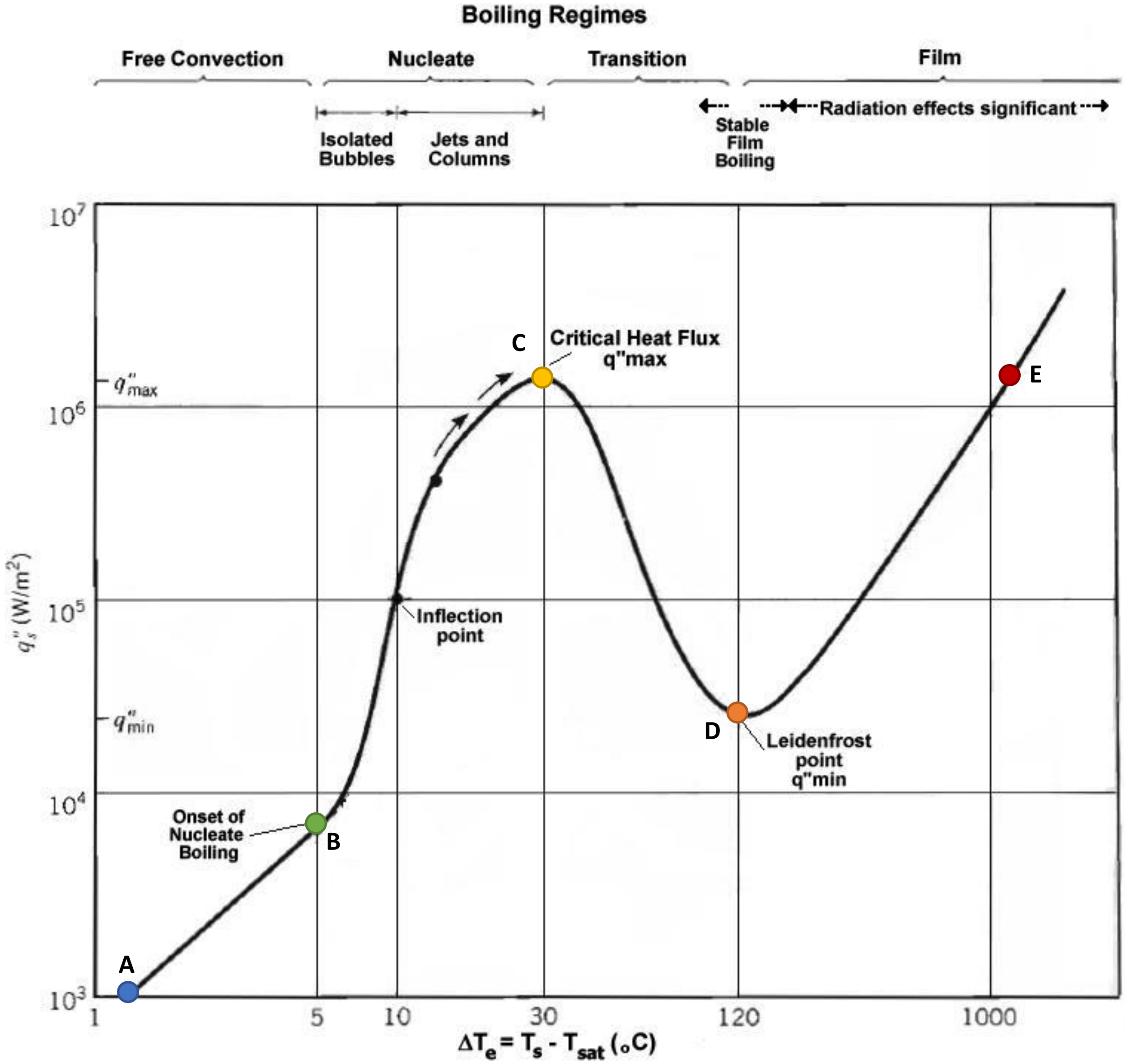

Boiling Curve for water at 1 atm.
Surface heat flux q" as a function of excess temperature $\Delta T_e = T_s - T_{sat}$

<u>Points</u>: A: (1.3, 1000) B: (5, 7000) C: (30, $1.5\text{x}10^6$) D: (120, $2.5\text{x}10^4$) E: (1200, $1.5\text{x}10^6$)

<u>Note</u>: This graph is a log-log plot (both axes are on a logarithmic scale) so the normal equation for linear interpolation won't work. Instead, use the following equations:

$$y = y_0 \left(\frac{x}{x_0}\right)^m, \qquad m = \frac{log\left(\frac{y_1}{y_0}\right)}{log\left(\frac{x_1}{x_0}\right)}$$

In python, `log(x)` is the natural logarithm and `log10(x)` is the base-10 logarithm.

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You'll now work on taking your linear approximation of the boiling curve, and creating a program that can evaluate it for you (given an excess temperature, calculate and report the surface heat flux).

Next, consider what values you need to store, and the general steps you will need to follow in your program.

- [10] Make a list of the variables you think you will need, and the names you will use.
- [10] Create a sequence of steps that you will follow
    - If you have a conditional statement (you should have a few!), you might want to indicate each part of the condition as a separate action
    - The computation will involve a few stages. Please separate the stages into different parts; do not just say "compute surface heat flux".

Next, create a list of test cases that you will use in your program. Be sure to handle both "typical" and "edge" cases. **Do this before writing the program itself!**

- [20] Similar to the group activity, for each test case provide the input, the expected output, and identify the type of case ("typical" or "edge")
- [10] Note that you should try to come up with a complete set of test cases that thoroughly test the idea (you should have **at least** 10 test cases)
- [10] Your program should handle input excess temperatures outside the provided range on the graph by printing a message to the screen

Your PDF should contain your variable list, your sequence of steps, and your test cases.

<u>Activity #2</u>**: Boiling curve – individual [40%] submit on ZyBook**

AFTER doing Activity #1, construct your program and name the file boiling_curve.py. Submit on Zy Book. Your program should ask users for an excess temperature, and report the surface heat flux. As you write your program, please be sure to do the following:

- Remember debug your code before put input from the user part. Then add user input and check if it is working.
- Include comments for your program. It's a good idea to begin by converting your list of steps into comments.
- Develop incrementally. Write some code then test it before writing the next section of code.
- Be sure your program runs and passes all of your test cases. You can submit your code as many times as you want to zyBooks. This is a good way to check your code and see if it passes Dr. Ritchey's test cases.
- Your code should output in the format below, rounding to the nearest integer for the calculated surface heat flux.

Example output (using input: **3**)

```
Enter the excess temperature: 3
The surface heat flux is approximately 3347 W/m^2
```

Example output (using input: **-1**)

```
Enter the excess temperature: -1
Surface heat flux is not available
```

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[10] Make a list of the variables you think you will need, and the names you will use.

Variables I think I will need	Names I will use
X value/ excess temperature	x
Initial X value at first given point	x0
Initial Y value at first given point	y0
Initial X value at second given point	x1
Initial X value at second given point	y1
Slope	m
Y value/ surface heat flux	y

[10] Create a sequence of steps that you will follow

If you have a conditional statement (you should have a few!), you might want to indicate each part of the condition as a separate action

The computation will involve a few stages. Please separate the stages into different parts; do not just say "compute surface heat flux".

I will make 5 if statements. The first one will be "if 1.3 <= x < 5.0". The second one will be "if 5.0 <= x < 30.0". The third one will be "if 30 <= x < 120". The fourth one will be "if 120 <= x <= 1200". The fifth one will be "if x > 1200 or x < 1.3". Then Ill give values to the variables x0, y0, x1, and y1 (They will be different values for each if statement depending on which points are being used on the graph). Then using those values I'll write an equation to calculate the slope (m). Then using the slope (m), the variables I gave values to from the graph points (x0, y0, x1, y1), and the x value inputted (x) I will write an equation to calculate the surface heat flux (y)

$$Equation\ for\ surface\ heat\ flux\ I\ will\ be\ using \rightarrow \left(y = y_0\left(\frac{x}{x_0}\right)^m\right)$$

$$Equation\ for\ slope\ I\ will\ be\ using \rightarrow\ (m = \frac{log\ \left(\frac{y_1}{y_0}\right)}{log\ \left(\frac{x_1}{x_0}\right)})$$

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Next, create a list of test cases that you will use in your program. Be sure to handle both "typical" and "edge" cases. Do this before writing the program itself!

[20] Similar to the group activity, for each test case provide the input, the expected output, and identify the type of case ("typical" or "edge")

[10] Note that you should try to come up with a complete set of test cases that thoroughly test the idea (you should have at least 10 test cases)

[10] Your program should handle input excess temperatures outside the provided range on the graph by printing a message to the screen

#	Case Type	Case description, case base, purpose (Edge cases test situations where one parameter is at an extreme) (Typical cases	Input	Expected output
1	Typical	Put a typical value between 1.3 to 5 that tests the first if statement.	2	1863
2	Typical	Put a typical value between 5 to 30 that tests the second if statement.	20	445247
3	Typical	Put a typical value between 30 to 120 that tests the third if statement.	100	42835
4	Typical	Put a typical value between 120 to 1200 that tests the fourth if statement.	500	316241
5	Typical	Put a typical value where x > 1200 or x < 1.3 to test the fifth if statement.	1300	Surface heat flux is not available
6	Edge	Put an edge value between 1.3 to 5 that tests the first if statement.	1.3	1000
7	Edge	Put an edge value between 5 to 30 that tests the second if statement.	5	7000
8	Edge	Put an edge value between 30 to 120 that tests the third if statement.	30	1500000
9	Edge	Put an edge value between 120 to 1200 that tests the fourth if statement.	120	25000
10	Edge	Put an edge value where x > 1200 or x < 1.3 to test the fifth if statement.	1201	Surface heat flux is not available