程序代写代做 CS编程辅导

Lecture 18

# Project Prep


**Agenda for the class:**

**Prep for the Project**

**Doing Real-World Math with the MCU**

**Q-Format Numbers**

**CCS Tools: Load Memory & Graph**

**In class coding demo**

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# Last Time: Stack Frames

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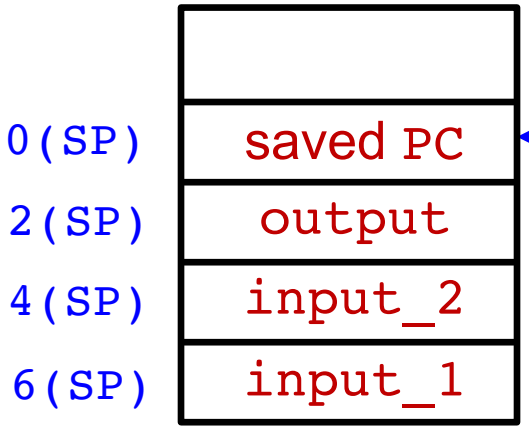
The subroutine contract specifies the structure of the **stack frame**

e.g., a stack frame with tw[illegible]lues and one output value

subroutine will see when it is first called

- Caller pushes `input_1`, then `input_2`
- With the subroutine call `PC` is placed onto the stack
- Subroutine
  - reads `input_1` and `input_2`
  - computes and writes `output` into the stack frame
  - `ret` removes `PC` from stack
- Caller
  - reads `output` from stack frame
  - cleans up the rest of the stack

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# Temporary Variables on Stack

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We can also create a similar structure in stack without calling a subroutine

⇒ **Dynamic data allocat**

e.g., copy of an array with ts `x = {x(0), x(2), x(4), x(6)}`

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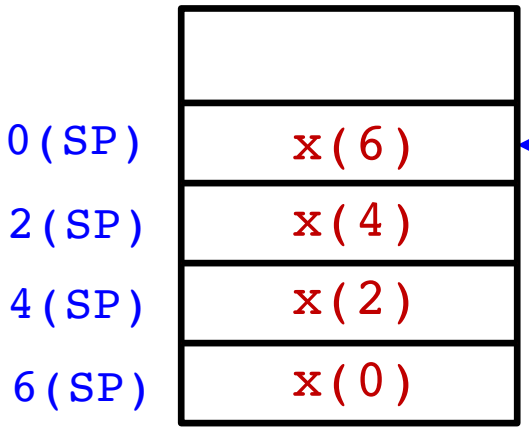


```
        clr.w    R4
rep:    push     x(R4)
        incd.w   R4
        cmp.w    #8, R4
        jne      rep
        ...
        add.w    #8,  SP
```

**release memory on stack after use!!**

# Project

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**(Tentative) Task:** You will be given some information buried in noise and you will recover it

Will use sin(x) and cos(x) as a basis of information

- Find a way of dealing with *fractional* numbers in code and CCS
- Load data into memory. sin(x), cos(x), data points will be provided in a file
- Plot the graph of sin(x), cos(x), data points
- Project the data points to sin(x) and cos(x) to find the buried information

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You will write two subroutines:

- Inner product
- Signed multiplication

These can use the subroutines we have already developed: e.g., x_times_y

# Fixed-Point Rational Numbers

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There is only so much math we can do with integers only

We cannot even properly [illegible] a power of two: 27/4 = 6.75

We can write this number [illegible] with integer and fractional part

```
110.11 = 4 + 2 + 1/2 + 1/4 = 6.75
1010.10 = 10.5
0.01 = 0.25
11.00 = 3.00
```

**Note:** Demo only. Never find decimal values like this!

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All these numbers have **2 fractional bits** after the radix point

⇒ Fixed-point representation with two fractional bits

⇒ Called **Q2** format by Texas Instruments with **Q Value 2**

**This is only how we interpret a binary sequence, HW does not care !!**

# Q Format

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**What does Q Value mean?**

Q Value alone is incompl[illegible]ve to consider the number of bits too

A 16-bit signed number w[illegible]e 2 is well defined:

`0x002B = 0000 0000 0010 1011`

= $(10.75)_{10}$

**signed Q(14.2) number**

**14 integer bits** **2 fractional bits**

imagine a radix point here

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An 8-bit **signed** number with Q value 7

**signed Q(1.7) number**

`0xF2 = 1111 0010`

radix point here

**7 fractional bits**

Value in decimal ? Complicated!

# Q Format to Decimal Conversion

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**Good news:** It is easy if you do it the easy way

**Better news:** You will ma[illegible]o it for you (most of the time)

**What is the easy way?**

Do not attempt to add up place values – too complicated with (–)ve numbers

Instead, divide the integer value of the number by the **correct power of two**

**i.e., the Q value**

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An 8-bit signed number with **Q value 7**

`0xF2 = 1111 0010`

radix point here

7 fractional bits

Integer value of `0xF2` is `-14`

Shifting radix point 7 positions to the left means dividing the number by $2^7 = 128$

$\Rightarrow$ decimal value of `0xF2` in Q(1.7) format is

`-14/128 = -0.0546875`

# Q Format ↔ Decimal

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All you need is a Hex ↔ Decimal convertor and a calculator

`0xD1C8 = (-11832)10`

signed!

6.0) the decimal value is -11832 / $2^0$

4.2) -11832 / $2^2$

Q(8.8) -11832 / $2^8$

Q(1.15) -11832 / $2^{15}$

**Q value 0**

**Q value 15**

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If we want to convert from decimal to Q format

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**We have to watch the range of numbers!!**

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e.g., Q(1.15) can represent only numbers in the range **[– 1, 1)**

**open**

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Once you fix the range, multiply by the **correct power of 2**

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5.245 in Q(9.7): 5. 245 x $2^7$ = 671.36 approx. `0x029F`

**Q value 7**

# Q Format Arithmetic

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**This is only how we interpret a binary sequence, HW does not care !!**

**Addition and subtractio**  **y**

- Let the HW do add an
- Just make sure to only subtract numbers in the same Q format corresponds to aligning the radix point when adding and subtracting

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**Multiplication is easy too but watch the format change**

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- Let the HW multiply
- Always watch for overflow – Q format or not!

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- **The Q values are added!!**

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same as decimal point placement in decimal multiplication

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Multiplying a Q(1.**7**) number with a Q(2.**5**) number $\Rightarrow$ Q(4.**12**) number

x / $2^{7}$ y / $2^{5}$ xy / $2^{12}$

# Changing between Q Formats

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**Decreasing the Q value without changing the encoded value**

e.g., from Q(1.7) to Q(4.4) – Q value decreases from 7 to 4

```
0.1000000 = 0x80  =>  0.1000 = 0x04
```

both numbers encode decimal value 0.5

**Shift** the radix point 3 positions to the **right** = **divide** by $2^{7-4} = 2^3$

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**Increasing the Q Value**

e.g., from Q(8.0) to Q(4.4) – Q value increases from 0 to 4

```
00000001. = 0x01  =>  0001.0000 = 0x10
```

both numbers encode decimal value 1.0

**Shift** the radix point 4 positions to the **left** = **multiply** by $2^4$

# Motivation

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**Why do we need all this?**

Because there is so much more numbers than integers

e.g., sin(x) produces numbers in the range [– 1, 1]

without fractions the result would be, only a square wave!

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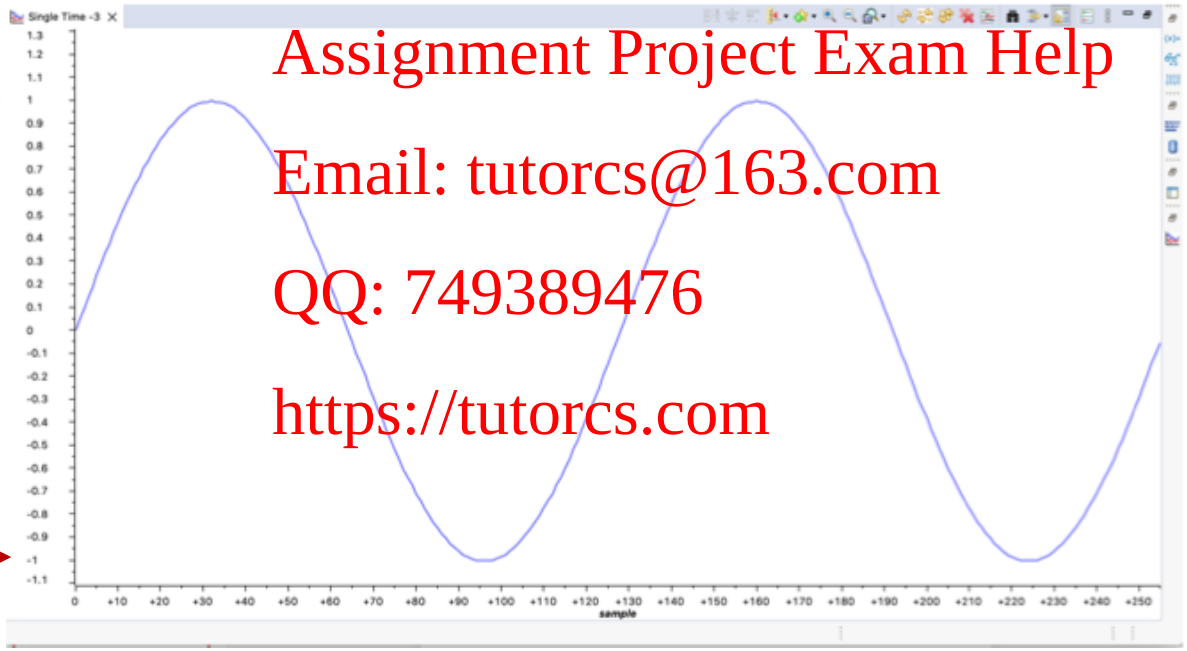
For the project we will use sin(x) – and more

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properly!

# Importing Data into the MCU

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CCS enables importing external data into the RAM/FRAM of the MCU

Several file formats are s[illegible]we will use TI Data format

*magic number*

[illegible]rting [illegible]dress (hex)

length in words (hex)

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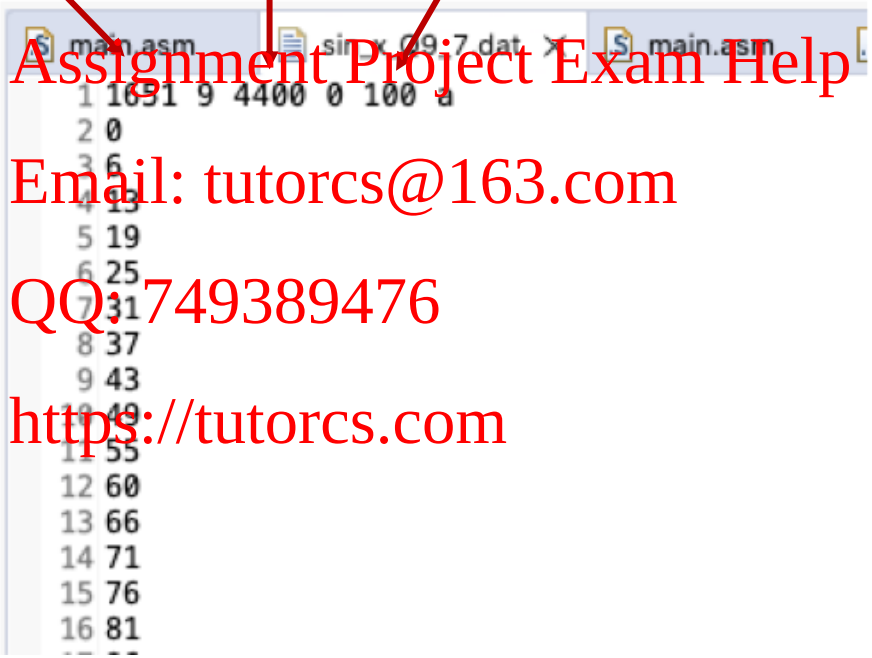
header line




one data sample per line

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# Importing Data into the MCU

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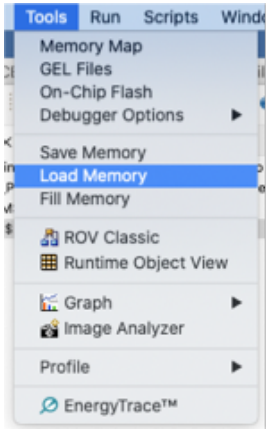
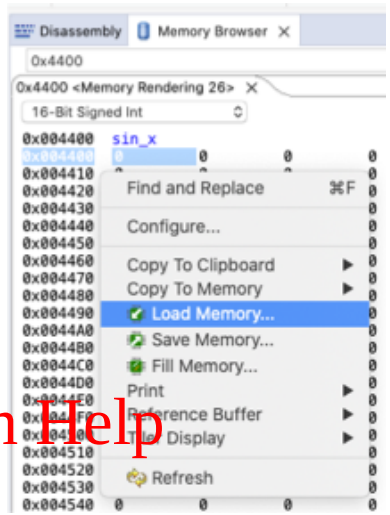
You can import data **only during an active debug session**

Find “Load Memory” unde s Tab




vely, right click inside the memory browser and select ”Load Memory”

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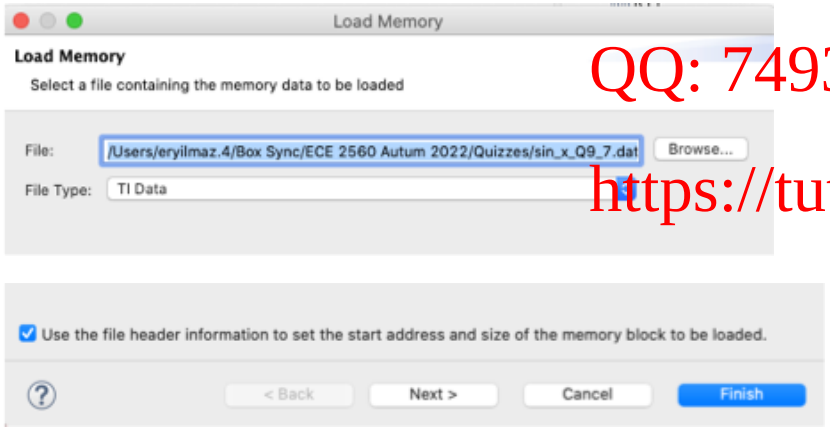
Browse for the file you want to upload in the “Load Memory” dialogue




Make sure to check the box at the bottom: Use the file header information…

To confirm starting address and length if necessary hit “Next”

Hit “Finish”

# Configuring the Q Format

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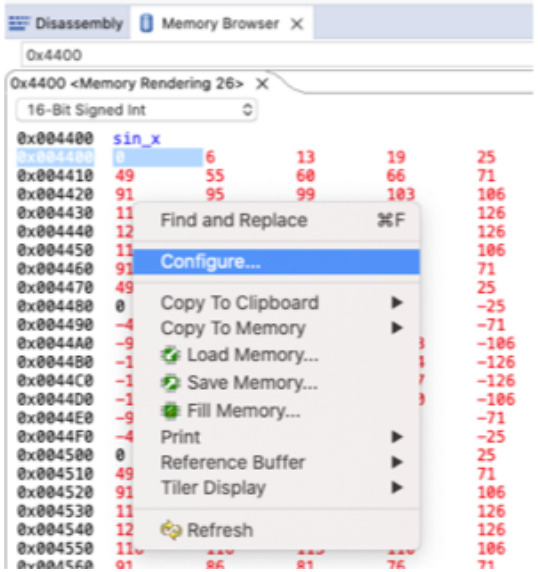
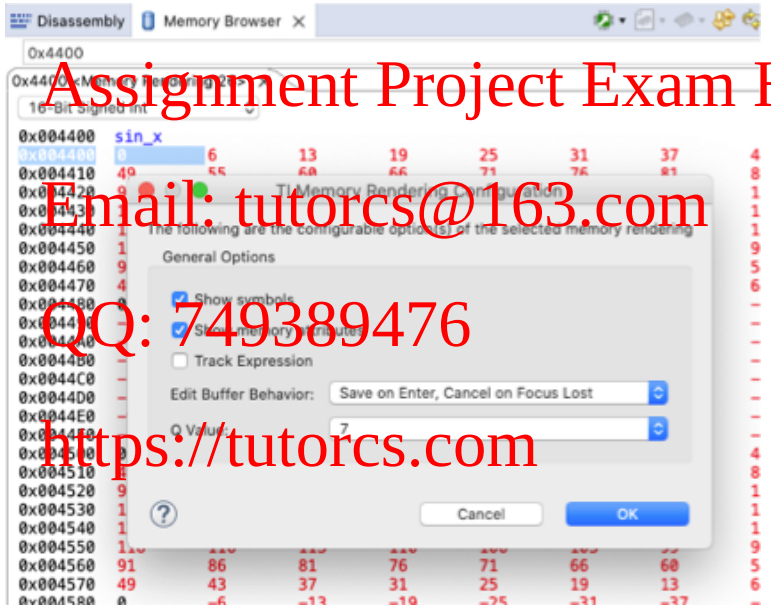
You will see the values in the file populate the MCU memory

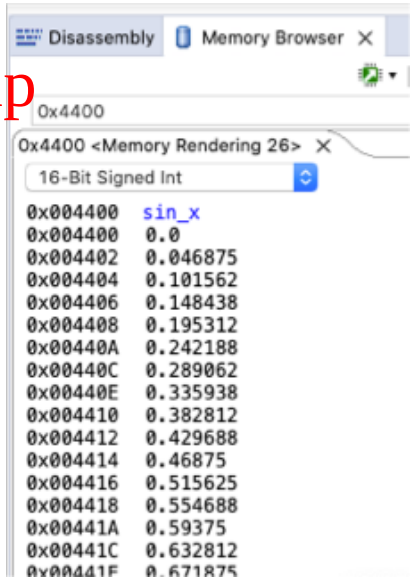
Choose “16-bit Signed Int” right click on the memory browser to access the “Configure” option




Select the Q value that is associated with the data




CCS will display fractional values

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# Graphing

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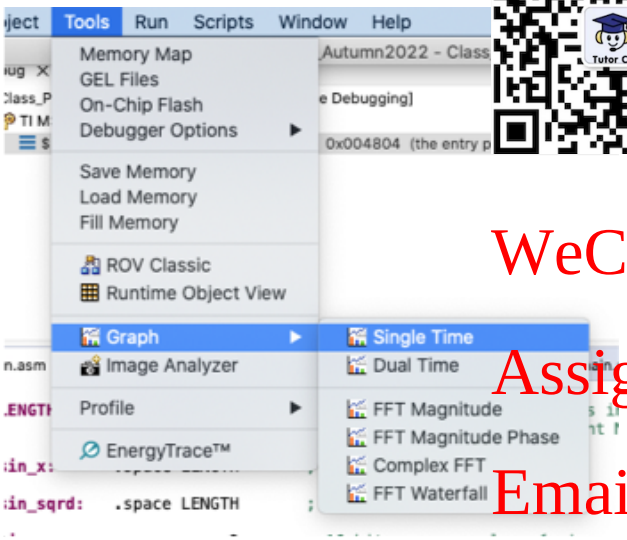
You can graph **only during an active debug session**

Find “Graph >> Single Tir[redacted] the Tools Tab




Populate the marked fields in the “Graph Properties” dialogue including the right Q Value

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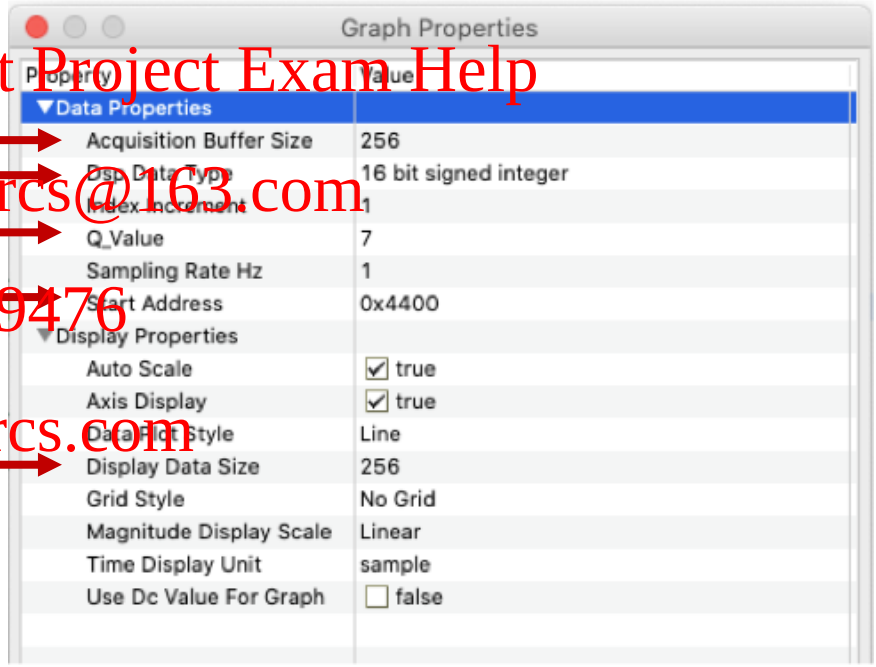


Double check that all fields are filled with the correct parameters and hit “OK”

# Graphing

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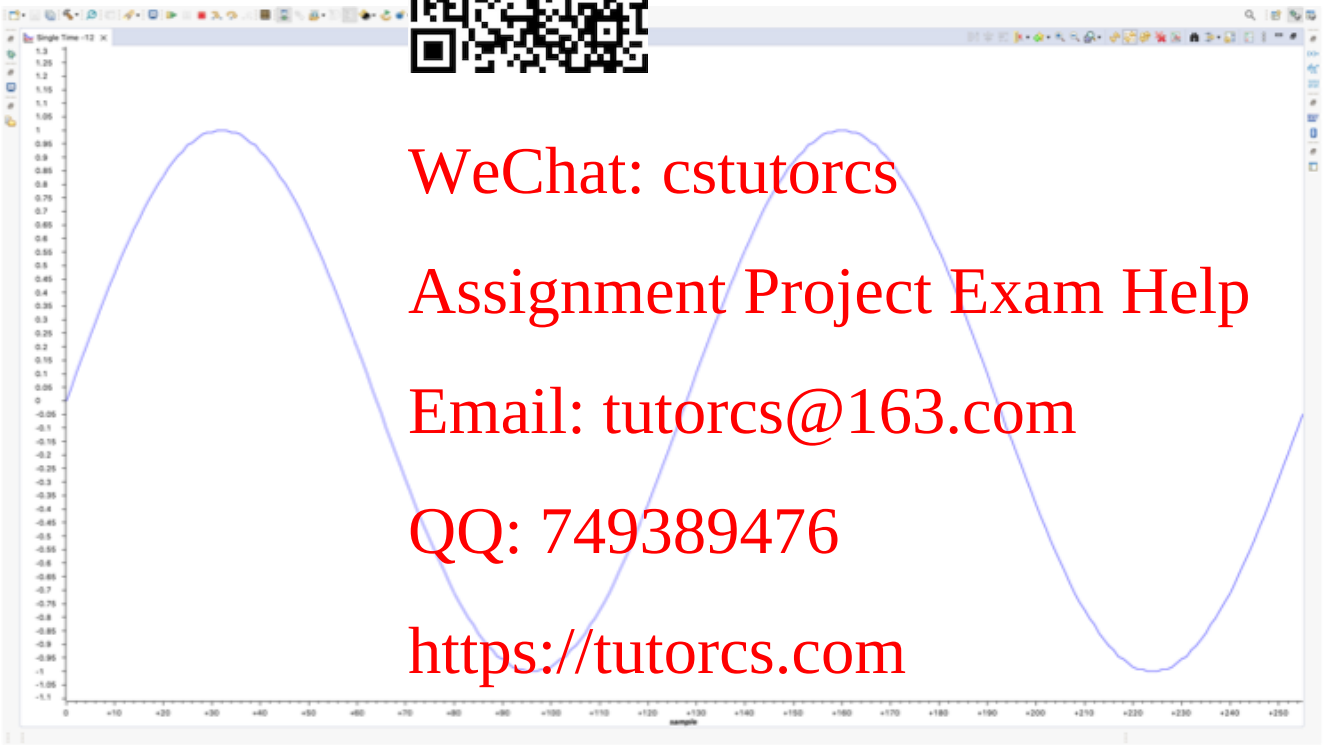
CCS will graph the values in the specified memory locations

Double check axes and v[illegible]ey are not correct make necessary adjustments in the “Graph[illegible]s” dialogue



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