

iiSME Educational Transfer Plan

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ETP Type
Subject Area: 12th Grade Physics
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Intro to Programming Using MATLAB

0. Abstract

The goal of this ETP is to introduce students to computer programming in MATLAB that is heavily used in scientific and engineering research, especially in a university research facility like Stanford. Students will first learn basic commands to input and output data in the form of vectors and matrices. Once students have learned how to draw flowcharts when planning to write a more complex programs, they will learn to use sample data or ones from instruments to do simple data analysis using MATLAB.

I. Standards/Skills/Objectives/Assessment

1. Focal Standard or Skill:

NGSS High School Engineering, Technology, and Application of Sciences Standards 1-1 to 1-4

1) Students who demonstrate understanding can:
a. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

b. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

c. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

d. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

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2. Measurable Objective(s):

1. Students will be able to create written code for simple programs using equations that students have learned in their math or science classes.
2. Students will draw basic flowcharts on how to use if-then-else and other reclusive programing statements.
3. Students will demonstrate basic programming skills using MATLAB

3. Assessment:

Formative Assessment: Basic input/output commands by hand and drawing flow charts. To see if students understand the basic if-then-else conditional commands, students will draw a flowchart based on a given conditional statement.

Summative Assessment: Given an equation students have learned in their classes (math, physics, etc.), they will write a MATLAB program that will calculate the answer as well as give error messages if the inputs are in the wrong format.

4. Additional Standards: N/A

II. Fellowship Connections

1. 21st Century Skill(s):

ICT (Information, Communications and Technology) LITERACY

- Apply Technology Effectively Use technology as a tool to research, organize, evaluate and communicate information
- Use digital technologies (computers, PDAs, media players, GPS, etc.), communication/networking tools and social networks appropriately to access, manage, integrate, evaluate and create information to successfully function in a knowledge economy

2. 21st Century Skill(s) Application:

Students will learn programming through a programming language called MATLAB that is heavily used in science and engineering research in data collection and analysis.

3. Fellowship Description:

This summer, I am working at a lab at Stanford that is researching on nano material. My focus will be to use tools like MATLAB to analyze the data collected by instruments like voltmeter and ammeter to on these materials. I will also be exposed to how the lab uses these instruments and sensors on materials that are invisible to our naked eyes. During the first few weeks of my fellowship, I will be researching on background information on these nanomaterials by reading relevant papers from researchers from different parts of the world. The process will allow me to see the global collaboration that is involved in a research like this.

4. Fellowship Connection to School/Classroom:

While a few of my students might be exposed to computer programming in languages like Python or even C++, it would be good even for those students to learn about other programming languages like MATLAB that is used so extensively in the fields of science and engineering. Also since all my physics students would have learned about matrices and solving system of equations, MATLAB would be a great way to help students review what they have learned about matrices in their math classes and see how they are applied in scientific research and data analysis.

END Proposal!

III. Instruction

1. Instructional Plan:

Introduction to Programming Using MATLAB

PART I: Planning a program using flowcharts

Before we start using the computers, students will learn to draw flowcharts on how to plan a program before writing and typing one. We will start by looking at a math equation many students have seen before, the quadratic formula:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

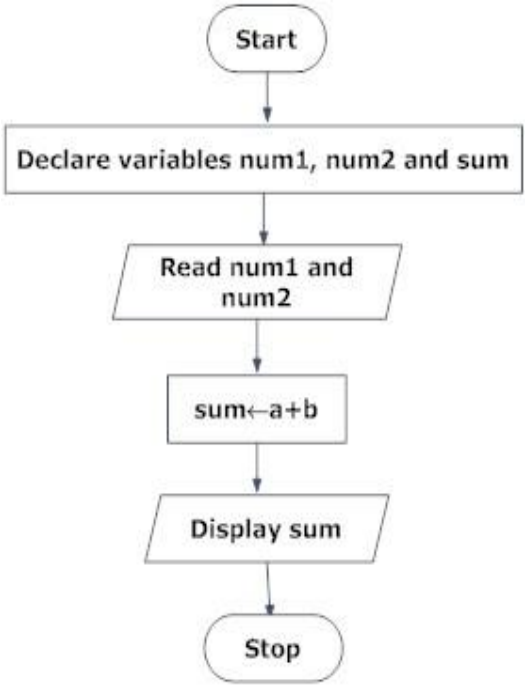
Ask the students questions like the following:

1) What is this equation used for? → To calculate x as output
2) When can we use this equation? → Is the equation in $ax^2 + bx + c = 0$form
3) What does the "$\pm$" mean? → 2 possible answers
4) What do we need to know to calculate x? → Values of a, b, and c as inputs
5) What if inside the square root calculate to a negative number? → Undefined or imaginary numbers
6) What if a is a zero? → Undefined or would not need this quadratic formula

As we can see, there are a lot of things our minds need to know before we can use an equation like this. Let's draw a diagram (or a flowchart) of our thinking process when using any equation. Let's start by reading how to do a draw a flowchart by reading the following article:

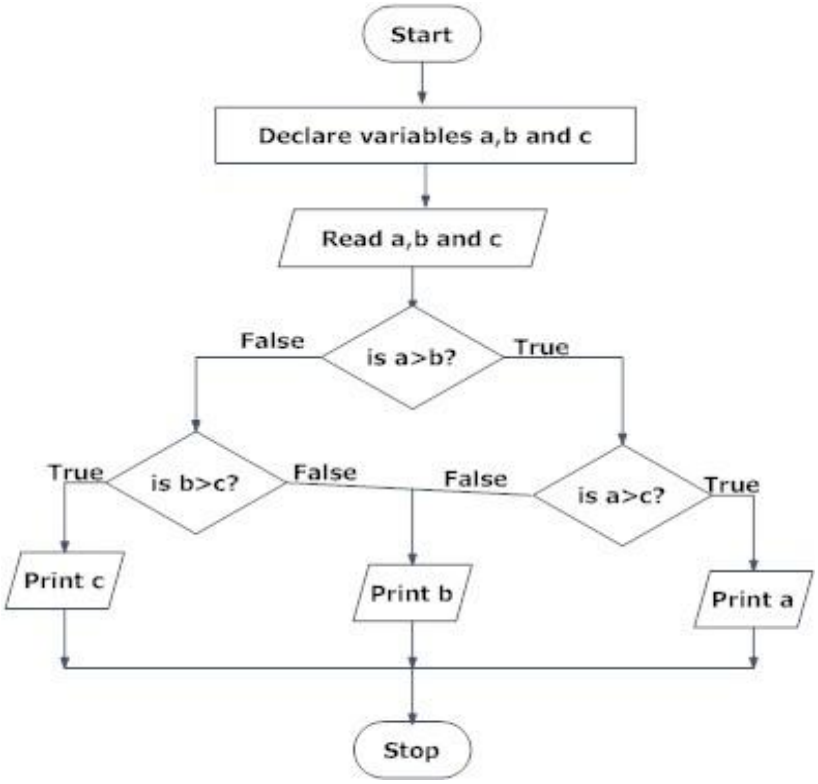
http://www.programiz.com/article/flowchart-programming

Ask the students what the different symbols we use in the flowcharts for making decisions, inputs, outputs, and the calculation processes. We can then draw a flowchart on how to use a few equations or formula based on the examples on that article.

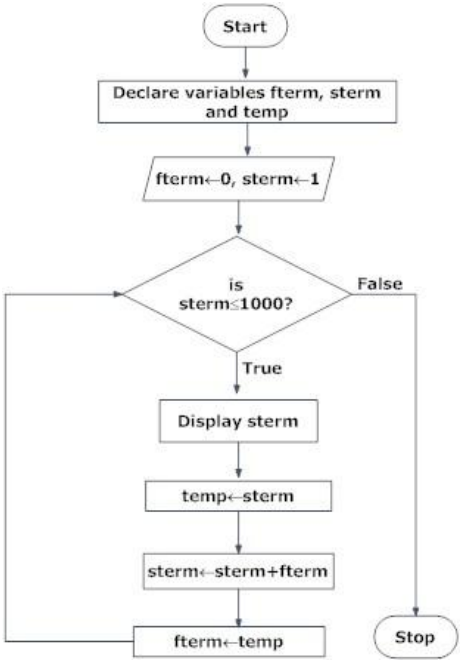


Other examples of flowcharts in programming:

Draw flowchart to find the largest among three different numbers entered by user.

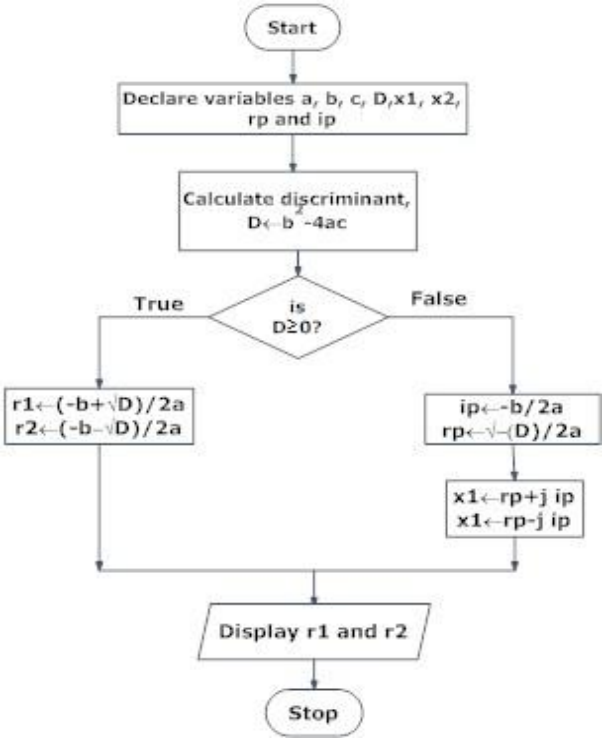


Draw a flowchart to find the Fibonacci series till term≤1000.



Formative Assessment:

Draw a flowchart to find all the roots of a quadratic equation $ax^2+bx+c=0$



Notes for Teachers: You may use other equations in physics, math, or any subject to have students draw a flowchart on the decision process to use that equation. For example, physics teachers can use $\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$. Basic geometry teachers can use area of a trapezoid is $\frac{1}{2}(b_1 + b_2)h$, etc. Students must also give sample values for the inputs and state what the output or the answer should be. For example, inputs of $b_1 = 3,\ b_2 = 4,\ and\ h = 5$ would produce an output of 30 as the area of the trapezoid.

PART II: Programming with MATLAB

Now let's have a computer program to do all these decision making and calculations for us. We will write a program call Quadratic (a, b, c) to calculate x for us. It will also give us the error messages if we give the program with values that don't make sense or if it will produce undefined or imaginary numbers as answers.

We will start by looking through these video on how to program in MATLAB:

http://www.mathworks.com/videos/writing-a-matlab-program-69023.html

Based on the video, have students look at the following program for Quadratic(a,b,c) would look like and copy it into their notebook.

```
function x = quadratic (a,b,c)

x1=(-b+sqrt(b^2-4*a*c))/(2*a);
x2=(-b-sqrt(b^2-4*a*c))/(2*a);

if (b^2-4*a*c) < 0

   disp 'ERROR: Roots are undefined or are imaginary numbers';

elseif (b^2-4*a*c) == 0

   x = x1;

else

x = [x1 x2];

end
```

Then have students go to their computers to open MATLAB and try out different commands they saw on the MATLAB video. They can then type the quadratic program on their computers and test out a few sample values for a, b, and c. For example, Quadratic(1, 5, 6) should produce an output answers of 2 and 3. Students can then try other different values.

Using the equations that the students wrote for their flowcharts in their formative assessment, have them work with partners to write MATLAB programs for their equations and test out their known values. They will need to show that their programs will produce the expected answers as output as the ones from their formative assessment's calculations.

Summative Assessment: Given an equation in physics or any subject, draw a flowchart and then write a MATLAB code to calculate one of the variables as output. The program should produce error messages also when given wrong types of input.

Click here for a grading rubric:
At the end of the lesson, show this video on what else programming in MATLAB can do and why it is important to learn a programming language like MATLAB.

http://www.mathworks.com/videos/matlab-overview-61923.html

2. Additional Instructional Context:

One thing I try to do with my students is to tell them that they should not have to memorize equations from my physics class. I would rather that they try to derive those equations and understand when to use them. Once they do, I don't mind if students program their equations into their calculators. Instead of teaching students how to program on their graphing calculators, they will learn to program their equations into their MATLAB codes instead. If enough students have smartphones, they can also use their login accounts on the mobile version of MATLAB.

3. Supply List:

Computer lab with MATLAB installed on all student computers and have internet access. (see attachments for price quotes as of July 2016)

4. Bibliography:

Flowchart in Programming. Programiz, Web. 21 July 2016.
<http://www.programiz.com/article/flowchart-programming>.

"MATLAB Overview." MATLAB Tutorial Videos. Mathworks, Web. 21 July 2016.
<http://www.mathworks.com/videos/matlab-overview-61923.html>.

5. Keywords:

MATLAB, Programming, Flowchart

IV. Attachments

1) Matlab Full License Quote

2) Matlab Subscription Quote

3) Summative Rubric