The University of Nottingham Ningbo China

Centre for English Language Education

SEMESTER TWO 2020-2021

INTRODUCTION TO MATHEMATICAL SOFTWARE & PROGRAMMING

Time allowed 2 hours

Candidates may complete and sign their attendance card but must NOT write anything else until the start of the examination period is announced.

This practical examination paper contains FOUR compulsory questions.

An indication is given of the weighting of each subsection of a question by means of a figure enclosed by square brackets, eg. [5], immediately following that subsection.

No calculators are permitted in this examination.

Dictionaries are not allowed with one exception. Those whose first language is not English may use a standard translation dictionary to translate between that language and English provided that neither language is the subject of this examination. Subject specific translation dictionaries are not permitted.

No electronic devices capable of storing and retrieving text, including electronic dictionaries, may be used.

Do not turn examination paper over until instructed to do so.

ADDITIONAL MATERIAL: *Guidelines and instructions*.

INFORMATION FOR INVIGILATORS:

1. *Please give a 15 minutes warning before the end of the exam.*
2. *Please collect Question Papers at the end of the exam.*

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1. One method to approximate the number π in GeoGebra is to evaluate the area under

$$f(x) = \frac{4}{(1+x^2)} \quad ; \quad 0 \leq x \leq 1.$$

(a) (i) In the settings change the rounding to 10 decimal places (d.p.).

(ii) Plot $y = \dfrac{4}{1+x^2}$ over $0 \leq x \leq 1$.

(iii) Make a slider n with Min=50, Max=200 and Increments=50.

(iv) In a CAS window and define two variables `U:=UpperSum()` and `L:=LowerSum()` and in each expression set the 'Number of Rectangles' to the slider value n.

(v) Define a new variable `myPI` and set it equal to the average of `U` and `L`.
Also define absolute error by $\left|\texttt{myPI} - \pi\right|$.

Save this file as **Q1a.ggb**. [5]

(b) Write a brief report of your numerical approximation of the number π in 1(a) in the form of a LaTeX article (use given template) with the following information:

(i) Create three sections as described below:

1) Motivation:

Write a few lines about the purpose of your computation in 1(a).

2) Explanation:

Explain (briefly) why $\int_0^1 f(x)\,dx$ is used for finding π.

3) Numerical calculations:

Create the following Table to summarise your numerical findings.

No of rectangles(n)	myPI (10 d.p.)	Absolute error (10 d.p.)
$n = 50$		
$n = 100$		
$n = 150$		
$n = 200$		

Table 1: Numerical calculations

Save the .tex file as **Q1b.tex**, and the generated PDF file **Q1b.pdf**. [10]

2. (a) Create a MATLAB script file **twoCurves.m** to generate a figure.

   (i) Use function handles to define the following mathematical expressions in MATLAB:

$$\begin{aligned} f(x) &= (\sin x + \cos x) \cdot (\cos x - 2), \\ g(x) &= e^{2\sin x}. \end{aligned}$$

   (ii) Plot the graphs of $y = f(x)$ and $y = g(x)$ in one frame where $-\pi \leq x \leq \pi$.

   Apply the following curve specifications:

   1) Line style/colour for $y = f(x)$ should be dashed/green, and for $y = g(x)$ it should be dotted/black.
   2) For both curves, set line width as 2.
   3) Grids on.
   4) Put your student ID as the title.

   Save the figure file as **twoPlots.png**. [5]

   (b) Create a beamer presentation with 5 slides with the following specifications.

   Note: Use the Beamer template given.

   Slide 1: Create a title slide with the presentation title: Two Interesting Curves.
   Add your Student ID, and today's date.

   Slide 2: Create a slide with the title: Table of Contents.
   This slide should display the table of contents (titles of Slides 3 to 5).

   Slide 3: Create a slide with the title: Two Curves.
   This slide should have two columns. The left column contains the following function definitions, and the right column contains the figure **twoPlots.png** from 2(a). It should include the caption: 'Two Curves'.

$$\begin{aligned} f(x) &= (\sin x + \cos x) \cdot (\cos x - 2) \\ g(x) &= e^{2\sin x} \end{aligned}$$

   Use a transition scheme such that the left column appears first, followed by the right column.

Slide 4: Create a slide with the title: Observations.

Make three blocks that appear one at a time (by using appropriate transitions)

Block 1: Title: Points of Intersection

Content: State how many points of intersection are there.

Block 2: Title: Question

Content: State how you can determine the points of intersection.

Block 3: Title: Min/Max

Content: State what can be said about maximum and minimum points of f and g.

Slide 5: Create a slide with the title: Summary.

Use hyperlink buttons to create links to all the previous slides.

Save the Beamer file as **presentation.tex**, and the generated PDF file **presentation.pdf**.

[10]

3. Create a MATLAB function file **splitmat.m** that takes an $n \times n$ $(n \geq 3)$ square matrix M, and splits M into an Upper-triangular matrix A, a Diagonal matrix B, and a Lower-triangular matrix C.

For example,

`>>[A, B, C] = splitmat(`$[1 \quad 2 \quad 3\,;\,4 \quad 5 \quad 6\,;\,7 \quad 8 \quad 9]$`)` should return:

`The Upper-triangular matrix` A `is:`

`0  2  3`

`0  0  6`

`0  0  0`

`The Diagonal matrix` B `is:`

`1  0  0`

`0  5  0`

`0  0  9`

`The Lower-triangular matrix` C `is:`

`0  0  0`

`4  0  0`

`7  8  0`

Explanation:

$$\begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{pmatrix} = \begin{pmatrix} 0 & 2 & 3 \\ 0 & 0 & 6 \\ 0 & 0 & 0 \end{pmatrix} + \begin{pmatrix} 1 & 0 & 0 \\ 0 & 5 & 0 \\ 0 & 0 & 9 \end{pmatrix} + \begin{pmatrix} 0 & 0 & 0 \\ 4 & 0 & 0 \\ 7 & 8 & 0 \end{pmatrix}$$

that is, $M = A + B + C$.

Save the MATLAB file as **splitmat.m**. [5]

4. <u>Note</u>:

   You must not use MATLAB in-built function `isprime` in this question.

   Create MATLAB function files as described below:

   (a) Create a MATLAB function file **primedisp.m** that takes a positive integer $p > 1$ and returns an array (row vector) of all the prime numbers from 1 to p, inclusive.

   For example, `>>primedisp(19)` should return: 2 3 5 7 11 13 17 19

   (b) Create a MATLAB function file **primelist.m** that takes two positive integers p, q $(2 \leq p < q)$ and returns an array with all the prime numbers between p and q, inclusive. You must use call function **primedisp.m** created in 4(a) in this function.

   For example, `>>primelist(10,20)` should return: 11 13 17 19

   (c) Create a MATLAB function file **primecheck.m** that takes a positive integer $p > 1$ and checks whether the input number is prime or not.

   You must use call function **primelist.m** created in 4(b) in this function.

   For example,

   `>>primecheck(455)` should return 455 is not a prime number.

   `>>primecheck(97)` should return 97 is a prime number.

   <u>Notes</u> (for 4(c)):

   1) Use appropriate `sprintf` and `disp` commands.
   2) Use a `while` loop to ask the user whether they want to try another number:
      Would you like to test another number [Y/N] ?

[15]

$\sim$ **END** $\sim$

Submission Checklist (Total 11 files)

Before submission to a designated drive, please make sure you have included the following files in your folder named as your **Student ID**.

- GeoGebra file:

  (1) **Q1a.ggb**

- Tex files:

  (2) **Q1b.tex**

  (3) **presentation.tex**

- Figure Files:

  (4) **twoPlots.png**

- PDF Files:

  (5) **Q1b.pdf**

  (6) **presentation.pdf**

- MATLAB m-files:

  (7) **twoCurves.m**

  (8) **splitmat.m**

  (9) **primedisp.m**

  (10) **primelist.m**

  (11) **primecheck.m**