

# Tahm — Waves Exam 3

April 29, 2025

This exam tests your fluency with the core of the Wolfram Language, as it was presented in *An Elementary Introduction to the Wolfram Language, 3rd Edition (EIWL3)*, Sections 25-34 and 38-41. There is one problem with two or three parts corresponding to each section. **Tip: all of them are meant to be quick. If you get bogged down, move on.**

## Directions:

After downloading this notebook, rename it with your first name in the filename. E.g., *Eli-Exam3.nb*, *Harper-Exam3.nb*, *Hexi-Exam3.nb*, *Jeremy-Exam3.nb*, *Rania-Exam3.nb*, *Tahm-Exam3.nb*, or *Walker-Exam3.nb*.

Then disconnect from the wifi and work the exam. Save your notebook early and often so that you don't lose work in progress.

**Your answers always go into the Wolfram Language Input cells that begin with a comment, e.g.,**

```
(* 1a *) foobar /@ Plus[Array]
```

**All your answers should execute and re-execute without warnings or error messages.**

You may refer to your downloaded copies of *EIWL3*, and anything else we developed in the course (like your cheat sheets!), but not to any web resources.

When you are done, save your notebook one last time, re-join the wifi, and then email it to me.

This exam was designed to require about 45 minutes, but if you need a full hour, that is ok. Everyone will stop at the one-hour mark.

## 1. Applying Functions (*EIWL3* Section 25)

(a)

Use **Map** with a *levelspec* to put a frame around each individual number in the array **Array[Plus, {10, 10}]** (we don't want frames around already-framed things — just one level of frames around the individual numbers).

```
In[58]:= (* 1a *)
```

```
Framed /@ Flatten[Array[Plus,{10,10}]]
```

```
Out[58]=
```

```
{2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 3, 4, 5, 6, 7, 8, 9, 10, 11,
12, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 5, 6, 7, 8, 9, 10, 11,
12, 13, 14, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 7, 8, 9, 10,
11, 12, 13, 14, 15, 16, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17,
9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 10, 11, 12, 13, 14,
15, 16, 17, 18, 19, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20}
```

(b)

Copy what you did in (a), but for this part, also turn the result into a grid using **Grid** and the “as an afterthought” syntax:

```
In[59]:= (* 1b *)
```

```
{Framed /@ Flatten[Array[Plus,{10,10}]]} // Grid
```

```
Out[59]=
```

```
2 3 4 5 6 7 8 9 10 11 3 4 5 6 7 8 9 10 11 12 4 5 6 7 8 9
```

```
In[60]:=
```

```
In[61]:=
```

## 2. Pure Anonymous Functions (EIWL3 Section 26)

(a)

Use the **#** and **&** notation to create an anonymous function that cubes whatever is given it, and then use **/@** to apply it to every member of the list **{1,2,3,4,5}**.

```
In[62]:= (* 2a *)
```

```
In[63]:= #^2 & /@ {1, 2, 3, 4, 5}
```

```
Out[63]=
```

```
{1, 4, 9, 16, 25}
```

(b)

Use the **#1**, **#2**, and **&** notation to create an anonymous function that divides its first argument by its second argument. Combine this with **Apply** and a *levelspec* to apply the function to

$\{\{1,2\}, \{2,3\}, \{3,4\}, \{4,5\}\}$ . Once you have this right, you will get  $\{\frac{1}{2}, \frac{2}{3}, \frac{3}{4}, \frac{4}{5}\}$ .

```
In[64]:= (* 2b *)
```

```
In[65]:= (#1 / #2) &@@@ {{1,2},{2,3},{3,4},{4,5}}
```

```
Out[65]=
```

$$\left\{\frac{1}{2}, \frac{2}{3}, \frac{3}{4}, \frac{4}{5}\right\}$$

### 3. Applying Functions Repeatedly (E/WL3 Section 27)

(a)

Use **Nest** to apply **Factorial** twice to  $\{1,2,3,4\}$ . If you have this right, 620,448,401,733,239,439,360,000 will be one of the elements of your answer.

```
In[66]:= (* 3a *)
```

```
Nest[Factorial, {1, 2, 3, 4}, 2]
```

```
Out[66]=
```

```
{1, 2, 720, 620 448 401 733 239 439 360 000}
```

(b)

Use **NestList** to apply **Factorial** three times to  $\{1,2,3\}$ , as well as showing the results of doing it 0, 1, and 2 times. If you have this right, you will have an insanely large result at the third step. Do not go any higher, or I do not know what will happen to your computer.

[illegible]

#### 4. Tests and Conditionals (EIWL3 Section 28)

(a)

Use **PrimeQ** and **/@** to generate a **True** or **False** list that is twenty elements long expressing which numbers in **Range[20]** are prime.

```
In[68]:= (* 4a *)
PrimeQ[#] & /@ Range[20]

Out[68]= {False, True, True, False, True, False, True, False, False, False,
          True, False, True, False, False, False, True, False, True, False}
```

(b)

Combine **PrimeQ** with **Select** to only list the numbers in **Range[20]** that are prime.

```
In[69]:= (* 4b *)
Select[Range[20], PrimeQ]

Out[69]=
{2, 3, 5, 7, 11, 13, 17, 19}
```

## 5. More About Pure Functions (EIWL3 Section 29)

(a)

Accomplish exactly the same thing as **Table[n\*(n-1)/2, {n,6}]** using **Array** and a pure function.

```
In[70]:= (* 5a *)

Array[#*(#-1)/2 &, 6]

Out[70]=
{0, 1, 3, 6, 10, 15}
```

(b)

Make some modifications to **FoldList[Plus, {1,2,3,4,5}]** so that it produces a list of the first 10 factorials. Instead of hand-coding the list up to 10, begin by first changing **{1,2,3,4,5}** to **Range[10]**

```
In[71]:= (* 5b *)
FoldList[Factorial[Range[10]], 10]

FoldList: Nonatomic expression expected at position 2 in
FoldList[{1, 2, 6, 24, 120, 720, 5040, 40320, 362880, 3628800}, 10]. ⓘ

Out[71]=
FoldList[{1, 2, 6, 24, 120, 720, 5040, 40320, 362880, 3628800}, 10]
```

## 6. Rearranging Lists (EIWL3 Section 30)

(a)

Use **Transpose** and one of the *levelspec* options to turn

**{{{1,uno},{2,dos},{3,tres}},{{4,cuatro},{5,cinco},{6,seis}}}** into  
**{{{1,2,3},{uno,dos,tres}},{{4,5,6},{cuatro,cinco,seis}}}**

```
In[72]:= (* 6a *)
Transpose /@ {{{1,uno},{2,dos},{3,tres}},{{4,cuatro},{5,cinco},{6,seis}}}}
Out[72]:=
{{{1, 2, 3}, {uno, dos, tres}}, {{4, 5, 6}, {cuatro, cinco, seis}}}
```

(b)

Use **Flatten** and a *levelspec* option to turn

{{{1,uno},{2,dos},{3,tres}},{{4,cuatro},{5,cinco},{6,seis}}} into  
 {{1,uno},{2,dos},{3,tres},{4,cuatro},{5,cinco},{6,seis}}

```
In[73]:= (* 6b *)
In[74]:= Flatten[{{{1,uno},{2,dos},{3,tres}},{{4,cuatro},{5,cinco},{6,seis}}},1]
Out[74]:=
{{1, uno}, {2, dos}, {3, tres}, {4, cuatro}, {5, cinco}, {6, seis}}
```

## 7. Parts of Lists (EIWL3 Section 31)

(a)

Use the magical **All** position (you will need to use **All** more than once) to turn

{{{Eli, Lerner},{Harper,Yonago},{Hexi,Jin}},{{Jeremy,Choy},{Rania,Zaki},  
 {Tahm,Loyd},{Walker,Harris}}} into  
 {{Eli,Harper,Hexi},{Jeremy,Rania,Tahm,Walker}}

```
In[75]:= (* 7a *)
{{{Eli, Lerner},{Harper,Yonago},{Hexi,Jin}}}[[All,1]]
{{Jeremy,Choy},{Rania,Zaki},{Tahm,Loyd},{Walker,Harris}}}[[All,1]]
Out[75]:=
{Eli, Harper, Hexi}
Out[76]:=
{Jeremy, Rania, Tahm, Walker}
```

(b)

Use a magical *negative positional argument* to extract {Jeremy,Rania,Tahm,Walker} from  
 {{Eli,Harper,Hexi},{Jeremy,Rania,Tahm,Walker}} and combine that with **Take** with a  
 different magical *negative* argument to extract {Tahm,Walker}.

```
In[77]:= (* 7b *)
Take[{{Eli,Harper,Hexi},{Jeremy,Rania,Tahm,Walker}}, 2]
Out[77]:=
{{Eli, Harper, Hexi}, {Jeremy, Rania, Tahm, Walker}}
```

```
In[78]:=
```

## 8. Patterns (EIWL3 Section 32)

(a)

Use **Cases** to choose the lists that begin and end with the same letter in this list of lists (but look ahead to part (b) before you solve part (a)):

```
{
  {"a", "l", "u", "l", "a"},
  {"a", "l", "o", "h", "a"},
  {"a", "r", "a", "r", "a"},
  {"b", "o", "n", "u", "s"},
  {"c", "i", "v", "i", "c"},
  {"d", "e", "b", "e", "d"},
  {"e", "l", "b", "o", "w"},
  {"z", "a"},
  {"z", "z"}
}
```

```
In[79]:= (* 8a *)
```

```
Cases[{
  {"a", "l", "u", "l", "a"},
  {"a", "l", "o", "h", "a"},
  {"a", "r", "a", "r", "a"},
  {"b", "o", "n", "u", "s"},
  {"c", "i", "v", "i", "c"},
  {"d", "e", "b", "e", "d"},
  {"e", "l", "b", "o", "w"},
  {"z", "a"},
  {"z", "z"}
}, {x_, __, x_}]
```

```
Out[79]=
```

```
{{a, l, u, l, a}, {a, l, o, h, a}, {a, r, a, r, a}, {c, i, v, i, c}, {d, e, b, e, d}}
```

```
In[80]:=
```

(b)

The pattern **BlankNullSequence** has the shorthand `___`. Use `___` to improve the pattern you used in Part (a) so that the two-letter list `{z, z}` is also included in your result.

```
In[81]:= (* 8b *)
```

```
In[82]:= Cases[{
  {"a", "l", "u", "l", "a"},
  {"a", "l", "o", "h", "a"},
  {"a", "r", "a", "r", "a"},
  {"b", "o", "n", "u", "s"},
  {"c", "i", "v", "i", "c"},
  {"d", "e", "b", "e", "d"},
  {"e", "l", "b", "o", "w"},
  {"z", "a"},
  {"z", "z"}
}, {x_, ___, x_}]
```

```
Out[82]=
{{a, l, u, l, a}, {a, l, o, h, a}, {a, r, a, r, a}, {c, i, v, i, c}, {d, e, b, e, d}, {z, z}}
```

## 9. Assigning Names to Things (EIWL3 Section 38)

(a)

Use **Module** to compute  $x = \text{Factorial}[10]$ , and then produce  $\{x, x^2, x^3\}$ .

```
In[83]:= (* 9a *)
```

```
In[84]:= Module[{x = Factorial[10]}, {x, x^2, x^3}]
```

```
Out[84]=
{3 628 800, 13 168 189 440 000, 47 784 725 839 872 000 000}
```

(b)

Inside **Module**, let  $\text{rangeSquared} = \text{Range}[10]^2$ , and then produce a list line plot of  $\text{rangeSquared}$  joined with  $\text{Reverse}[\text{rangeSquared}]$ .

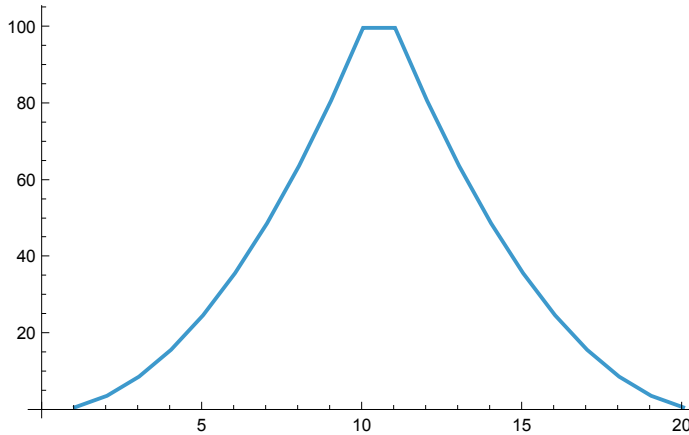
```
In[85]:= (* 9b *)
```



In[86]:=

```
Module[{rangeSquared = Range[10]^2},
  ListLinePlot[Join[rangeSquared, Reverse[rangeSquared]]]]
```

Out[86]=



## 10. Immediate and Delayed Values (EIWL3 Section 39)

(a)

Make a *one-character change* to this expression,

`Module[{x:=RandomInteger[10]}, {x, x2, x3, x4}]`, so that it produces four different powers of the same random number instead of four different powers of different random numbers.

In[87]:= `(* 10a *)`In[88]:= `Module[{x=RandomInteger[10]}, {x, x2, x3, x4}]`

Out[88]=

```
{5, 25, 125, 625}
```

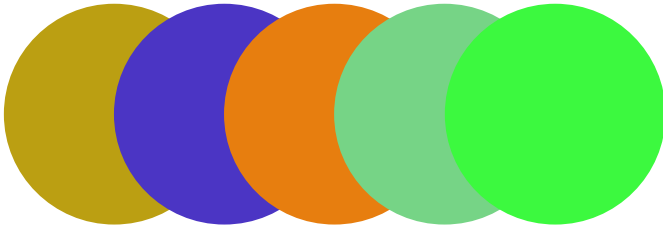
In[89]:=

(b)

Make a *one-character change* to this expression,

`Module[{color=RandomColor[]}, Graphics[Table[Style[Disk[{i,0}], color], {i, 5}]]]`, so that it produces five different-color disks.

```
In[90]:= (* 10b *)
Module[{color:=RandomColor[]},Graphics[Table[Style[Disk[{i,0}],color],{i,5}]]]
Out[90]=
```



## 11. Defining Your Own Functions (EIWL3 Section 40)

(a)

Define a function **f** that takes a list of three elements and out of them makes a list of lists that contains all six possible orderings. Using **Permutations** will make this easy.

Include a test of your function as **f[1,2,3]** and make sure it gets **{{1,2,3},{1,3,2},{2,1,3},{2,3,1},{3,1,2},{3,2,1}}**.

```
In[91]:= (* 11a *)
In[92]:=
In[93]:= f[1,2,3]
f[x_, y_, z_] := Permutations[{x, y, z}]
Out[93]=
{{1, 2, 3}, {1, 3, 2}, {2, 1, 3}, {2, 3, 1}, {3, 1, 2}, {3, 2, 1}}
```

(b)

Define a function **g** that gives **1** for **g[0]**, and gives **n\*g[n-1]** for any integer **n** greater than **0**, *but don't use an If statement!* Include a test of your function as **g[6]** and make sure it gets **720**.

```
In[95]:= (* 11b *)
g[6]
g[0] = 1; g[n_] := n * g[n - 1]
Out[95]=
720
```

## 12. More About Patterns (EIWL3 Section 41)

(a)

Use the replacement rule notation — e.g., **/.** and **->** — to exchange the first and last element in any list

containing two or more elements and test your replacement using the list `{alpha, beta, gamma, delta, epsilon}`.

```
In[97]:= (* 12a *)
In[98]:= {alpha, beta, gamma, delta, epsilon} /.
  {x___, a_, b_, c_, d_, y___} -> {y, a, b, c, d, x}
(*I couldn't get it for any length but here it is for a string length of 5*)
```

```
Out[98]:=
{epsilon, alpha, beta, gamma, delta}
```

```
In[99]:=
```

(b)

Starting with `Characters/@RomanNumeral[Range[100]]`, select all the sequences corresponding to the Roman numerals that have XXX in them.

```
In[100]:= (* 12b *)
Cases[Characters/@RomanNumeral[Range[100]],{___,"X","X","X",___}]
Out[100]:=
{{X, X, X}, {X, X, X, I}, {X, X, X, I, I}, {X, X, X, I, I, I}, {X, X, X, I, V},
 {X, X, X, V}, {X, X, X, V, I}, {X, X, X, V, I, I}, {X, X, X, V, I, I, I},
 {X, X, X, I, X}, {L, X, X, X}, {L, X, X, X, I}, {L, X, X, X, I, I},
 {L, X, X, X, I, I, I}, {L, X, X, X, I, V}, {L, X, X, X, V}, {L, X, X, X, V, I},
 {L, X, X, X, V, I, I}, {L, X, X, X, V, I, I, I}, {L, X, X, X, I, X}}
```

(c)

Use `StringJoin` to turn what you got in 12(b) into

`{XXX,XXXI,XXXII,XXXIII,XXXIV,XXXV,XXXVI,XXXVII,XXXVIII,XXXIX,LXXX,LXXXI,LXXXII,LXXXIII,LXXXIV,LXXXV,LXXXVI,LXXXVII,LXXXVIII,LXXXIX}`.

```
In[101]:= (* 12c *)
In[102]:= StringJoin /@ Cases[Characters/@RomanNumeral[Range[100]],{___,"X","X","X",___}]
Out[102]:=
{XXX, XXXI, XXXII, XXXIII, XXXIV, XXXV, XXXVI, XXXVII, XXXVIII, XXXIX, LXXX,
 LXXXI, LXXXII, LXXXIII, LXXXIV, LXXXV, LXXXVI, LXXXVII, LXXXVIII, LXXXIX}
```