

# Walker — Waves Exam 3

April 29, 2025

TOTAL SCORE / 25

Comments and Scores for Each Problem Are on Last Page

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[28]:= (* 1a *) Framed /@ Flatten@Array[Plus, {10, 10}]
```

```
Out[28]= {
  {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[29]:= (* 1b *) Grid[Array[Plus, {10, 10}], Frame -> All]
```

```
Out[29]=
```

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

## 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[30]:= (* 2a *) #^3 & /@ {1, 2, 3, 4, 5}
```

```
Out[30]= {1, 8, 27, 64, 125}
```

(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[31]:= (* 2b *) #1 / #2 &@@@ {{1,2},{2,3},{3,4},{4,5}}
```

```
Out[31]= {1/2, 2/3, 3/4, 4/5}
```

### 3. Applying Functions Repeatedly (EIWL3 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[32]:= (* 3a *) Nest[Factorial, {1, 2, 3, 4}, 2]
```

```
Out[32]= {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.

(a)

```
In[34]:= (* 4a *) PrimeQ /@ Range[20]
Out[34]= {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[35]:= (* 4b *) Select[Range[20], PrimeQ]
Out[35]= {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[36]:= (* 5a *) Array[#*{#-1}/2 &, 6] // Flatten
Out[36]= {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[37]:= (* 5b *) FoldList[Times, Range[10]]
Out[37]= {1, 2, 6, 24, 120, 720, 5040, 40320, 362880, 3628800}
```

## 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[38]:= (* 6a *) Transpose /@ {{{1,uno},{2,dos},{3,tres}},{{4,cuatro},{5,cinco},{6,seis}}}
Out[38]= {{{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[39]:= (* 6b *) Flatten[{{1, uno}, {2, dos}, {3, tres}}, {{4, cuatro}, {5, cinco}, {6, seis}}, 1]
Out[39]=
{{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[40]:= (* 7a *) {{{Eli, Lerner}, {Harper, Yonago}, {Hexi, Jin}},
               {{Jeremy, Choy}, {Rania, Zaki}, {Tahm, Loyd}, {Walker, Harris}}} [[All, All, 1]]
Out[40]=
{{Eli, Harper, Hexi}, {Jeremy, Rania, Tahm, Walker}}
```

```
In[41]:=
```

(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[42]:= (* 7b *) {{Eli, Harper, Hexi}, {Jeremy, Rania, Tahm, Walker}} [[-1, -2;; -1]]
Out[42]=
{Tahm, Walker}
```

## 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[43]:= (* 8a *) Stuff = {
  {"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"}
}
Cases[Stuff, {a_, ___, a_}]
```

```
Out[43]=
{{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}}
```

```
Out[44]=
{{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}}
```

(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[45]:= (* 8b *) Cases[Stuff, {a_, ___, a_}]
Out[45]=
{{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)

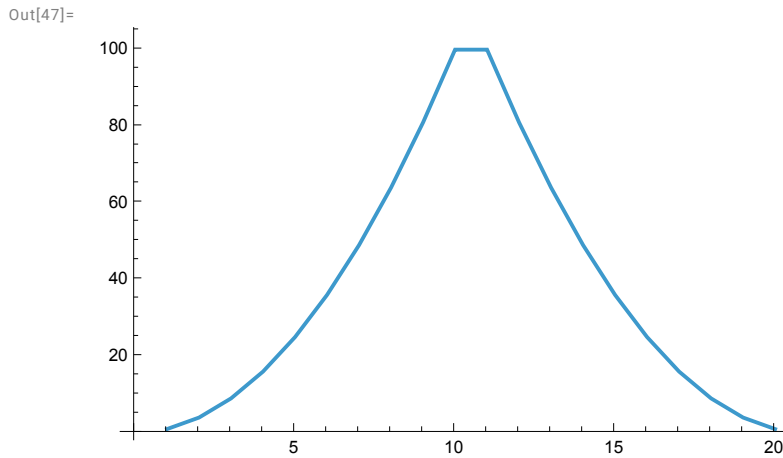
Use **Module** to compute `x=Factorial[10]`, and then produce `{x, x^2, x^3}`.

```
In[46]:= (* 9a *) Module[{x = Factorial[10]}, {x, x^2, x^3}]
Out[46]=
{3 628 800, 13 168 189 440 000, 47 784 725 839 872 000 000}
```

(b)

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

```
In[47]:= (* 9b *) Module[{rangeSquared=Range[10]^2},
  ListLinePlot[Join[rangeSquared, Reverse[rangeSquared]]]]
```



## 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[48]:= (* 10a *) Module[{x=RandomInteger[10]},{x,x2,x3,x4}]
```

Out[48]=  
{10, 100, 1000, 10 000}

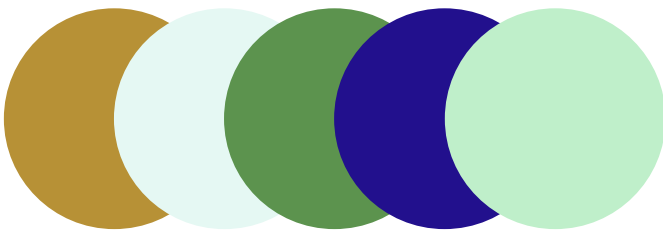
(b)

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[49]:= (* 10b *) Module[{color:=RandomColor[]},
  Graphics[Table[Style[Disk[{i,0}],color],{i,5}]]]
```

Out[49]=





## 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[50]:= (* 11a *) f[a_, b_, c_] = Permutations[{a, b, c}]
Out[50]=
{{a, b, c}, {a, c, b}, {b, a, c}, {b, c, a}, {c, a, b}, {c, b, a}}

In[51]:= f[1,2,3]
Out[51]=
{{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[52]:= (* 11b *) g[0] = 1; g[n_Integer] := n * g[n - 1]
g[6]
Out[53]=
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  
 $\{\text{alpha}, \text{beta}, \text{gamma}, \text{delta}, \text{epsilon}\}$ .

```
In[54]:= (* 12a *) Greek = {alpha, beta, gamma, delta, epsilon}
Greek /. {a_, b_, z_} -> {z, b, a}
Out[54]=
{alpha, beta, gamma, delta, epsilon}

Out[55]=
{epsilon, beta, gamma, delta, alpha}
```

(b)

Starting with **Characters/@RomanNumeral[Range[100]**, select all the sequences correspond-

ing to the Roman numerals that have XXX in them.

```
In[56]:= (* 12b *) Cases[Characters/@RomanNumeral[Range[100]], {a___, "X", "X", "X", b___}]
Out[56]=
{{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[57]:= (* 12c *) StringJoin@@@
Cases[Characters/@RomanNumeral[Range[100]], {a___, "X", "X", "X", b___}]
Out[57]=
{XXX, XXXI, XXXII, XXXIII, XXXIV, XXXV, XXXVI, XXXVII, XXXVIII, XXXIX, LXXX,
 LXXXI, LXXXII, LXXXIII, LXXXIV, LXXXV, LXXXVI, LXXXVII, LXXXVIII, LXXXIX}
```

1. Applying Functions   1   / 2

You really ignored the directions :( Map with a levelspec ... Copy what you did in (a), ...

2. Pure Anonymous Functions   1   / 2

2(a) perfect. For 2(b) directions were again to use a levelspec, but I'm impressed with your use of @@@ to elegantly get the job done.

3. Applying Functions Repeatedly      / 2

4. Tests and Conditionals      / 2

5. More About Pure Functions      / 2

6. Rearranging Lists      / 2

7. Parts of Lists      / 2

8. Patterns      / 2

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10. Immediate and Delayed Values      / 2

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12. More About Patterns      / 3