

# Harper — 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[191]:=

**Framed/@Level[Array[Plus,{10,10}],{2}]**

Out[191]=

```
{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[192]:=

**Framed/@Level[Array[Plus,{10,10}],{2}]/Grid**

Out[192]=

```
Grid[{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[193]:=

**#^3 & /@ {1, 2, 3, 4, 5}**

Out[193]=

{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[194]:=

```
Apply[#1 / #2 &, {{1,2},{2,3},{3,4},{4,5}}]
```

Out[194]=

```
{1/2, 2/3}
```

In[195]:=

```
Level[{{1,2},{2,3},{3,4},{4,5}},2]
```

Out[195]=

```
{1, 2, {1, 2}, 2, 3, {2, 3}, 3, 4, {3, 4}, 4, 5, {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[196]:=

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

Out[196]=

```
{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.



(b)

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

```
In[199]:=
Select[Range[20], PrimeQ]
Out[199]=
{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[200]:=
Table[n*(n-1)/2, {n,6}]
Out[200]=
{0, 1, 3, 6, 10, 15}

In[201]:=
Array[#*(#-1)/2 &, 6]
Out[201]=
{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[202]:=
FoldList[#2*#1 &, Range[10]]
Out[202]=
{1, 2, 6, 24, 120, 720, 5040, 40320, 362880, 3628800}

In[203]:=

In[204]:=

In[205]:=
```

## 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[206]:=

```
Table[Transpose[Part[{{1,"uno"},{2,"dos"},{3,"tres"}},{{4,"cuatro"},{5,"cinco"},{6,
```

Out[206]=

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

In[207]:=

(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[208]:=

```
Flatten[{{{1, "uno"}, {2, "dos"}, {3, "tres"}},
  {{4, "cuatro"}, {5, "cinco"}, {6, "seis"}}}, 1]
```

Out[208]=

```
{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[209]:=

```
Take[Level[{{{"Eli", "Lerner"}, {"Harper", "Yonago"}, {"Hexi", "Jin"}}, {"Jeremy", "Choy"
```

Out[209]=

```
{{Eli, Lerner}}
```

In[210]:=

```
foo[[3]]
```

 **Part:** Part specification `foo[[3]]` is longer than depth of object. 

Out[210]=

```
foo[[3]]
```

(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[211]:= Take[{{Eli,Harper,Hexi},{Jeremy,Rania,Tahm,Walker}},-1][[1]][{-1,-2}]
Out[211]= {Walker, Tahm}

In[212]:=

```

## 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[213]:= 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[213]= {{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}}

```

(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[214]:=

```
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[214]=

```
{{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[215]:=

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

Out[215]=

```
{3 628 800, 13 168 189 440 000, 47 784 725 839 872 000 000}
```

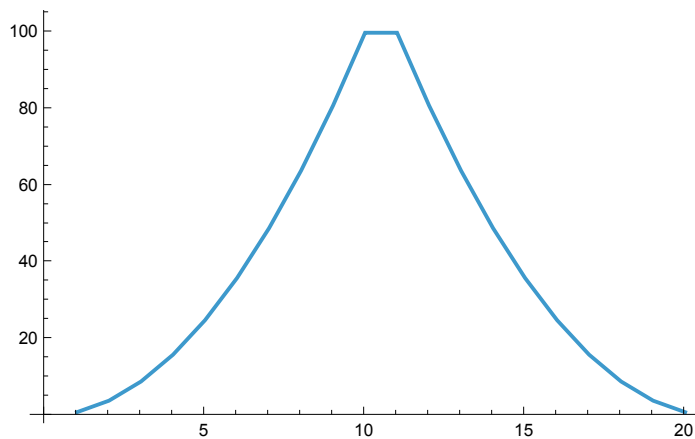
(b)

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

In[216]:=

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

Out[216]=





## 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[217]:=
Module[{x=RandomInteger[10]},{x,x2,x3,x4}]
```

```
Out[217]=
{0, 0, 0, 0}
```

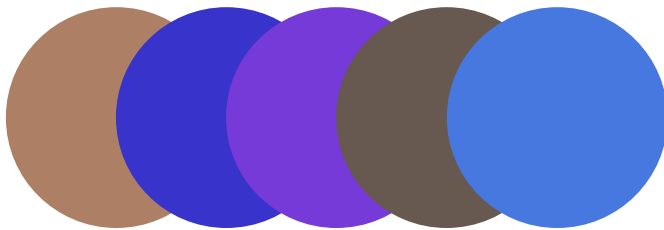
(b)

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[218]:=
Module[{color:=RandomColor[]},Graphics[Table[Style[Disk[{i,0}],color],{i,5}]]]
```

```
Out[218]=
```



## 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[219]:=
f[x_, b_, a_] := Permutations[{x, a, b}]
```

```
In[220]:=
f[1, 2, 3]
```

```
Out[220]=
{{1, 3, 2}, {1, 2, 3}, {3, 1, 2}, {3, 2, 1}, {2, 1, 3}, {2, 3, 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[221]:=

## 12. More About Patterns (E/WL3 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[222]:=

(\* 12a \*)

(b)

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

In[223]:=

(\* 12b \*)

(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[224]:=

(\* 12c \*)