Huffman Coding

Imagine the pages of a book. All those words. With all of the letters.

Could we use RLE to compress this data?

Huffman Coding

RLE isn't very helpful when trying to compress the data here - look at how many single letters there are on this page

Rather than `m`, we need to encode `1m` - that's more bits to encode

So `Huffman` (7 characters) would become `1H1u2f1m1a1n` (12 characters)

Huffman Coding

So using RLE to encode text like this is a bad idea because you rarely get long repeats of the same data item

We need a different way to compress this sort of data

Huffman Coding

ASCII code uses 7 bits for each character.

So, in a word like:

```
banana
```

each character is stored using 7 bits.

```
total bits = number of characters x 7
```

Huffman Coding

Languages all have some letters which are much more common than others.

What if we could use that to reduce the number of characters needed to encode each character?

In

```
banana
```

for example, there are 3 as, 2ns and 1 b

Huffman Coding

Huffman coding takes the most common letters in a block of text and encodes them using fewer bits

Less frequent characters are encoded using more bits

This allows us to use less bits in total

Huffman Coding

`woolloomooloo`

How often does each character appears?

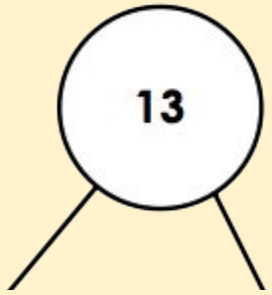
w	o	l	m

Huffman Coding

Once we know the frequency of each character we can build a **Binary Tree** to store each letter that appears in the text

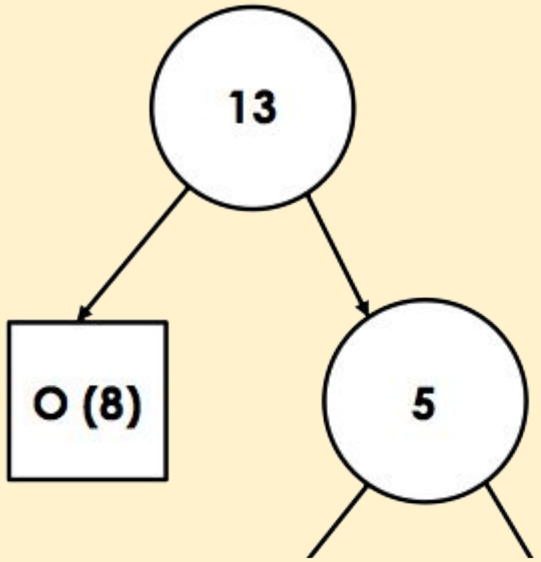
woolloomooloo

o	8
l	3
m	1
w	1



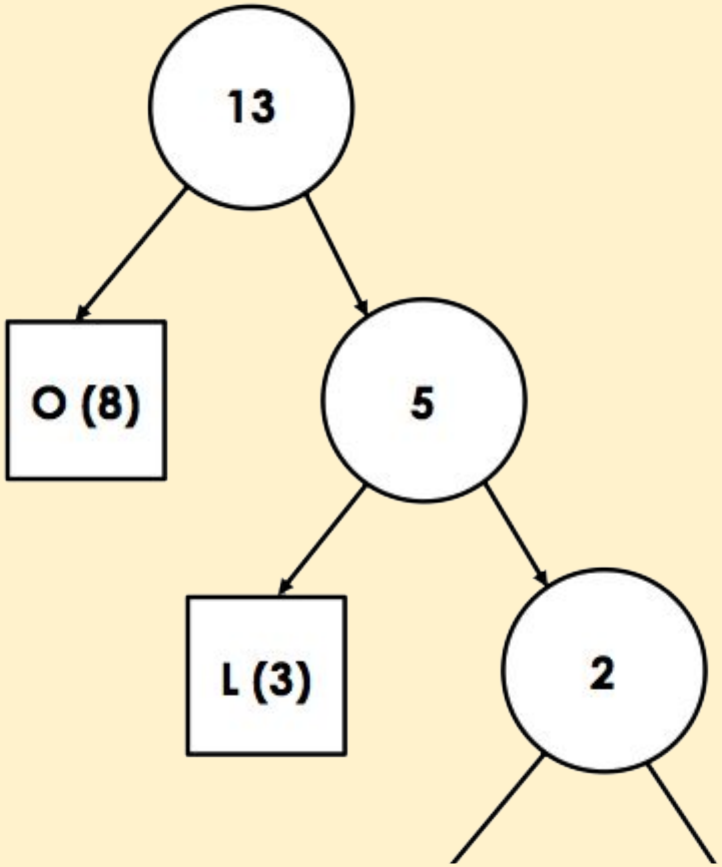
woolloomooloo

o	8
l	3
m	1
w	1



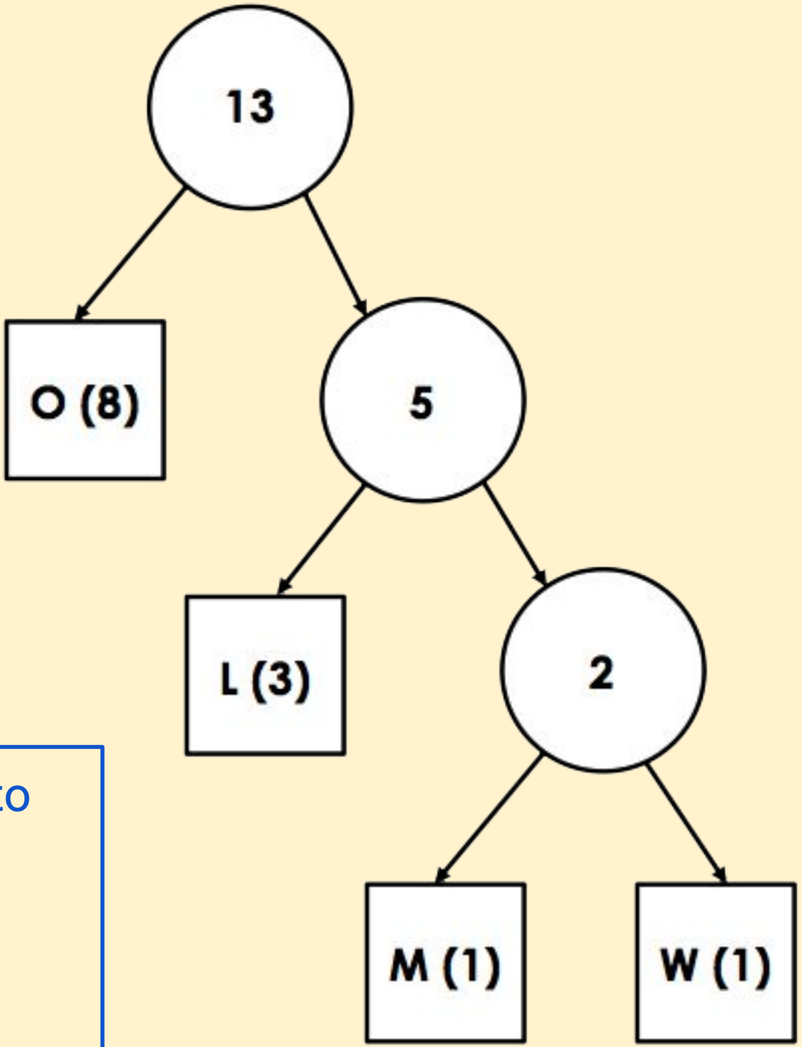
woolloomooloo

o	8
l	3
m	1
w	1



woolloomooloo

o	8
l	3
m	1
w	1

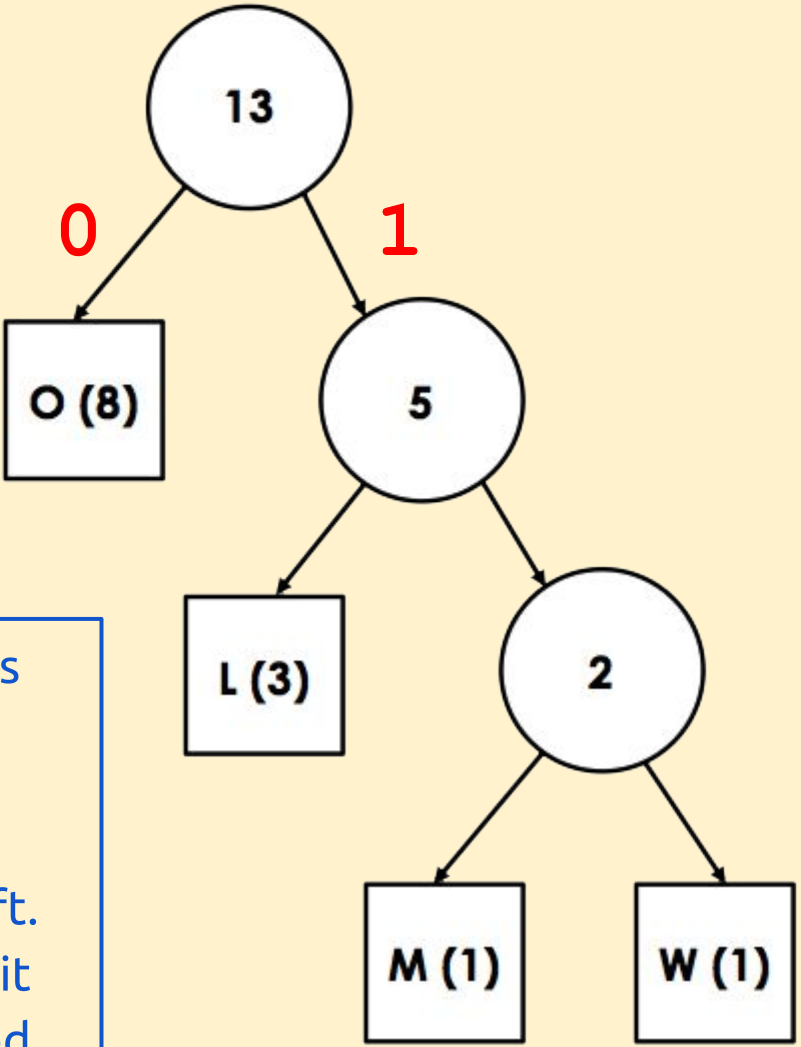


You don't need to know how to build a Huffman tree

You just need to know how to use one

woolloomooloo

o	8
l	3
m	1
w	1

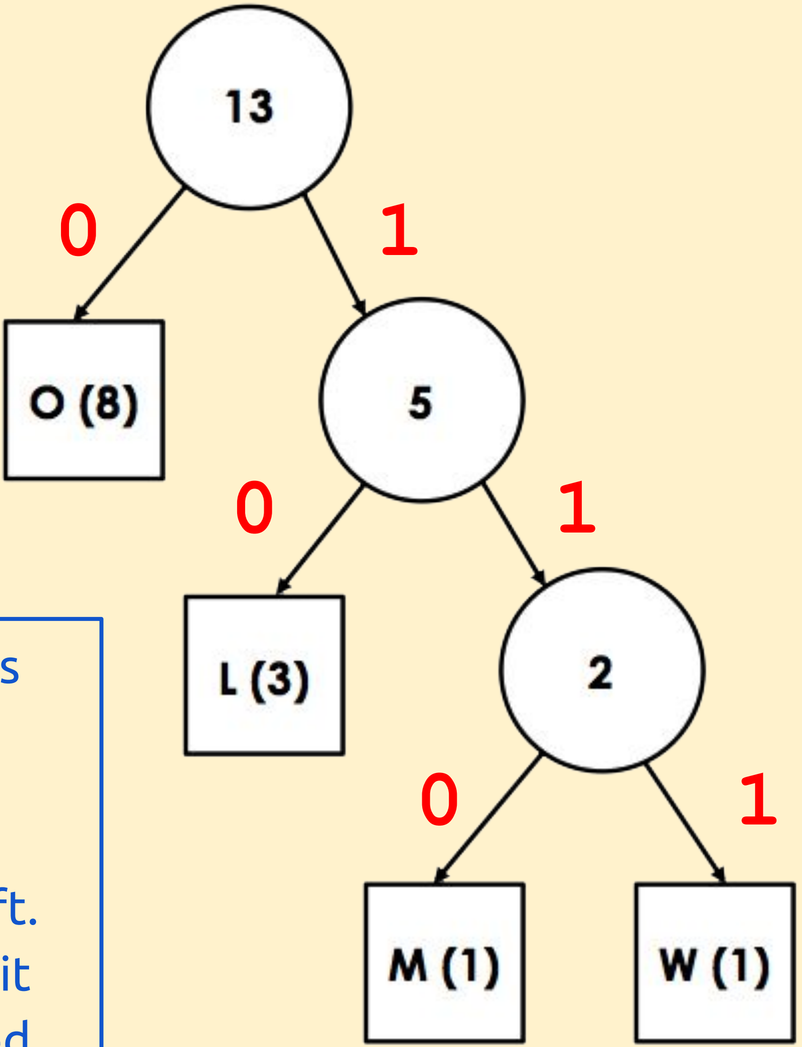


The exam board almost always uses **0 on the left** in Huffman Trees

Other sources put 1 on the left. The exam paper should make it clear what coding is being used

woolloomooloo

o	8
l	3
m	1
w	1



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Huffman Coding

The Huffman Tree gives us a way of encoding each character we used:

Character	**Huffman Coding**	**Memory**
o	0	1 bit
l	10	2 bits
m	110	3 bits
w	111	3 bits

Remember: ASCII is **always** 7 bits per character

Huffman Coding

So, using the Huffman Tree

```
woolloomooloo
```

becomes

```
11100101000110001000
```

with gaps

```
111 0 0 10 10 0 0 110 0 0 10 0 0
```

Huffman Coding

Space needed

`woolloomooloo`

ASCII = 13 character x 7 bits = 91 bits

Huffman Tree:

`11100101000110001000`

= 20 bits

Space **saving** = 91 - 20 = 71 bits