## Starter

Write down the line of code required to **declare** a variable called `age` to store a person's age. Choose a sensible data type.

```
int age;
```

## Starter

Write down the line of code required to **assign** your age to the variable age.

```
age = 100;
```

## Starter

Write down the code required to print `"College age"` if `age` is at least 16.

```
if (age >= 16)
{
  Console.WriteLine("College age");
}
```

# Binary

10110

This number is in binary.

What is binary?
What is this number in base 10?

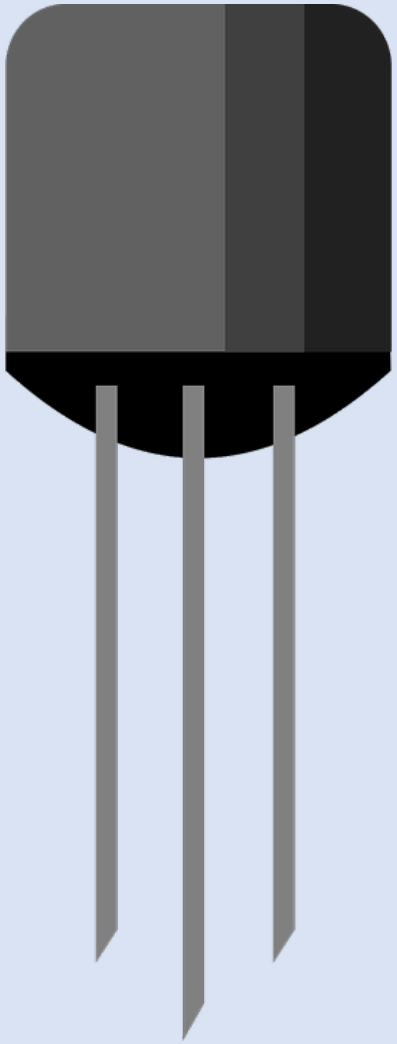
# Binary and Hexadecimal Number Bases

# Denary/decimal

- Denary/decimal (remember both names!) is the number system you are most familiar with
- It is base 10
- Each digit in a number represents a power of 10
- e.g. 123
  - 3 units, 2 tens, 1 hundred
- The base of a number system states the number of possible options for each digit
  - Base 10 has 10 digits (0, 1, 2, 3, 4, 5, 6, 7, 8, 9)
- Representing 10 different digits electronically would be complicated

# Transistors

- Transistors are tiny electronic components that act as switches with a little extra circuitry
- These switches are either on or off
  - or 1 or 0
  - or “set” or “not set”
- We can use these switches to represent digits, but only if each digit has only two possible options
- Introducing binary…



# Binary

- Binary is **base 2**: each “place” represents a power of 2
  - In 10110, there are 0 units, 1 two, 1 four, 0 eights and 1 sixteen
  - 2 + 4 + 16 = 22
- Each digit is a binary digit, so we call it a “bit”

# Converting between binary and denary

- How do we convert from binary to denary?
- How do we convert from denary to binary?
- The trick is to draw little tables
  - Similar to place value in school
- Make notes!

How do we count in binary?

# Practice

Convert

14

into binary

1110

# Practice

Convert
101011
into denary

43

# Practice

Convert

51

into binary

110011

# Practice

Convert
1000110
into decimal

70

# Exercise

Complete the table

| Binary | Decimal |
|---|---|
| 11100 | 28 |
| 100101 | 37 |
| 10010 | 18 |
| 110001 | 49 |
| 1001001 | 73 |
| 11001100 | 204 |
| 1011000 | 88 |
| 10011011 | 155 |
| 100110101 | 309 |

# Bits, nibbles & bytes

- A bit is a single binary digit (e.g. a 0 or a 1)
- A nibble is 4 bits (e.g. 1010)
- A byte is 8 bits (e.g. 10001111)

# The picture so far

- We know about denary/decimal, but it isn't so useful for computers
- We have seen binary, but it's difficult for humans to read and converting between binary and denary can be cumbersome

What if we had a number system that was easier for humans to read than binary, and easier to convert to/from binary?

# Hexadecimal

- Hexadecimal (hex, for short) is the base 16 number system
  - We have 16 digits
- Each digit represents a power of 16
  - $1, 16, 256, \ldots$
- We sometimes use special notation to indicate that a number is in hexadecimal
  - $1A_{16}$ or $1A_h$ or 0x16

| Digit | Value |
|---|---|
| 0 | 0 |
| 1 | 1 |
| … | … |
| 9 | 9 |
| *A* | 10 |
| *B* | 11 |
| *C* | 12 |
| *D* | 13 |
| *E* | 14 |
| *F* | 15 |

# Converting between hexadecimal and decimal

- How do we convert from hexadecimal to decimal? $0x1A$
- How do we convert from decimal to hexadecimal? $44$
- Once again, the trick is drawing little tables.

- How do we count in hex?

# Practice

Convert

18

into hexadecimal

12

# Practice

Convert

0x2C

into denary

44

# Practice

Convert

60

into hexadecimal

3C

# Practice

Convert

$1AA_h$

into decimal

$426_{10}$

# Exercise

Complete the table

| Hexadecimal | Decimal |
|---|---|
| *B* | 11 |
| *E* | 14 |
| 1*D* | 29 |
| 1*A* | 26 |
| 26 | 38 |
| 12*A* | 298 |
| *C*8 | 200 |
| 28*E* | 654 |
| *CAB* | 3243 |

# Hexadecimal and binary

- What is the largest value that can be stored with one hexadecimal digit?
  - 16
- So, how many bits are required to store one hex digit?
  - 4 – a nibble
- Considering each hex digit as a nibble makes converting between hex and binary very manageable

# Practice

Convert

0x18

into binary

11000

# Practice

Convert
101111011
into hex

17*B*

# Practice

Convert

$11FFEE_{16}$

into binary

0001 0001 1111 1111 1110 1110

# Practice

Convert

1111101011001110

into binary

*FACE*

# Types and Conversions

# What is a data type?

# Examples

- So far, we have used:
  - `int`
  - `string`
  - `double`
  - `bool`
- Others exist too
  - `float`
  - `char`

# Data types

- A **data type** describes the values that a particular variable or constant can take
- It describes how those values are stored
- Data types are used to define operations
  - e.g. + works differently for integers to strings
- Sometimes we need to convert data from one type to another

# Expressions and literals

- An expression, much like in maths, can be evaluated to a single value
  - e.g. `4 + 4`
- A literal is a hard-coded value that does not need to be evaluated
  - e.g. `8`
  - e.g. `"Hello, world!"`
- A literal is a type of expression

# Decimal numbers

- Decimal numbers are stored as a `float`
- We'll look at what this means, and why the word "float" is relevant in a future lesson
- We can also store decimal numbers as a `double`
  - This is the same as a float, but with *double* the number of bits used to store the number
- In C#, unless specified otherwise, it is assumed that decimal numbers are doubles
  - `3.2` is a `double`
  - `3.2f` is a `float` (appending `f` to the end of a number makes it a `float`)

# `char` and `string`

- A `char` is a single character (e.g. a letter, digit or symbol)
  - We use single quotes to write `char` literals (e.g. `'a'`)
- A `string` is a sequence of characters
  - We use double quotes to write `string` literals (e.g.`"apple"`)

# `bool` and conditions

- A `bool` (or Boolean) can take one of two values: `true` or `false`
- Conditions (e.g. `name == "Alex"`) evaluate to Booleans
  - They are expressions, just like `4 + 4`

# Type conversions

- Widening conversions
  - All integers can also be represented as doubles, but not all doubles can be represented as integers
  - Hence, `int` ⟶ `double` is a **widening** conversion
  - These happen implicitly (we don't have to tell C# to do it)
- Narrowing conversions
  - When converting from a type to a more specific type, that is a **narrowing** conversion
  - It is possible to convert `double` ⟶ `int`, for example
  - But we have to be explicit about it

# Casting

- Casting is the process of manually converting a value from one type to another
- It is not possible to cast to every type
  - e.g. we cannot cast an `int` to a `string`

```
double temperature = 21.6;
int castTemperature = (int) temperature;
```

- What will the value of `castTemperature` be?
- 21 – doubles are truncated when cast to integers

# Rounding

```
int roundedDouble = Math.Round(10.5); // 10

int anotherRoundedDouble = Math.Round(10.5,
MidpointRounding.AwayFromZero); // 11
```

- `Math.Round` defaults to banker's rounding: it will round to the **nearest even number**
- You can use `MidpointRounding.AwayFromZero` to change this

# Parsing

- Consider the following strings:
  - `"true"`
  - `"3"`
  - `"false"`
  - `"3.14"`
- They all represent values in other types
  - But, in their current form (strings), we can't use them like that
  - We can't add `"3.14"` to another number, because it's a string
- **Parsing** is the interpretation of a string into a value that it represents
  - We can parse `"3.14"` (a `string`) to `3.14` (a `double`)

# Parsing in practice

- All basic data types have a `.Parse` function
  - This is particularly helpful when consuming user input (e.g. with `Console.ReadLine()`, which always returns a `string`)

```
string boolString = "true";
string doubleString = "-4.5";

bool parsedBool = bool.Parse(boolString);
double parsedDouble = double.Parse(doubleString);
```

# Conversion to strings

- Sometimes it's useful to go the other way (to convert to a string)
- All basic data types have a `.ToString` function, but we have to call it on the *value*, not the type itself

```
double pi = 3.14;
string strPi = pi.ToString();
```

# Practice

For each of the following, write down how the conversion would be done

- `double` ⟶ `int`
  - Using a cast
- `char` ⟶ `string`
  - Using `.ToString`
- `string` ⟶ `double`
  - Using `double.Parse`
- `int` ⟶ `double`
  - Implicitly – no explicit conversion is required

# Extension

- Try typing `Convert.` into your program
- Explore the different options
- Can you figure out what’s happening?