### 1. Math Machines

The **expression** combines the two *operands* (6 and 2) with the addition *operator* (+) to produce a result of 8. The **equation** can be depicted graphically as shown to the right. We can interpret this as 6 and 2 being the *inputs* to the **ADD** machine and 8 as the *output*!

a) Similar math machines can be depicted for subtraction, multiplication and division. Supply the missing *inputs* and *outputs* to the **SUB**, **MUL** and **DIV** math machines below.

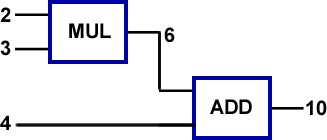
|  |  |  |
| --- | --- | --- |
|  |  |  |

b) What choices do we have for the *inputs* to these math machines?

c) Is there a machine that will break down if you feed it the wrong input?

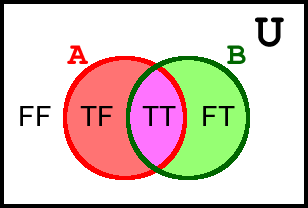
d) If we know only **one** input and the output, can we determine what the other input must be? If so, complete the following machines.

|  |  |  |
| --- | --- | --- |
|  |  |  |

We can build more complex math machines out of the basic machines above. The equation, can be depicted by the *two-level* machine to the right. The inputs are 2, 3, and 4. The number 6 is an *intermediate output* with 10 being the **final** output.

e) Draw the *two-level* math machine that corresponds to the equation.

### 2. Logic Machines

 We can apply this new idea of **math machines**, to the Boolean concepts we explored in our previous worksheet to produce the idea of **logic machines**!

Let’s summarize the knowledge we built up last class that combined (John) **Venn diagrams** with (George) **Boolean operators**.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Operator** | **OR** | **NOR** | **AND** | **NAND** |
| **Venn**  **Diagram** |  |  |  |  |
| **Truth**  **Table** | |  |  |  |  | | --- | --- | --- | --- | | **OR** | | **B** | | | **F** | **T** | | **A** | **F** | F | T | | **T** | T | T | | |  |  |  |  | | --- | --- | --- | --- | | **NOR** | | **B** | | | **F** | **T** | | **A** | **F** | T | F | | **T** | F | F | | |  |  |  |  | | --- | --- | --- | --- | | **AND** | | **B** | | | **F** | **T** | | **A** | **F** | F | F | | **T** | F | T | | |  |  |  |  | | --- | --- | --- | --- | | **NAND** | | **B** | | | **F** | **T** | | **A** | **F** | T | T | | **T** | T | F | |
| **Machine**  **Symbol** |  |  |  |  |

The **logic machine** representation of the Boolean equation, , is shown below, left. The **logic machine** representation of the Boolean equation, is shown below, right.

|  |  |
| --- | --- |
|  |  |

a) Complete the **logic machines** below.

|  |  |  |  |
| --- | --- | --- | --- |
| *i*) | *ii*) | *iii*) | *iv*) |

b) A *three-input, two level* logic machine appears below, left. For its given inputs, evaluate the final output, using D as an intermediate result. Now, as the last exercises in our fantastic introduction to computer math, summarize ALL possible results of this machine in the table below, right.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | |  |  |  |  |  | | --- | --- | --- | --- | --- | | **A** | **B** | **D** | **C** | **Output** | | **F** | **F** |  | **F** |  | | **F** | **F** |  | **T** |  | | **F** | **T** |  | **F** |  | | **F** | **T** |  | **T** |  | | **T** | **F** |  | **F** |  | | **T** | **F** |  | **T** |  | | **T** | **T** |  | **F** |  | | **T** | **T** |  | **T** |  | |