

Paper 1

Question 1

- a. Area is 0.0
- b. One solution is the following:

```
public class Circle
{
    private double radius;

    public Circle (double r)
    {
        radius = r;
    }

    public double getArea ()
    {
        return 3.14*radius*radius;
    }

    public static void main(String args[])
    {
        Circle c = new Circle (5.0);
        System.out.println ("Area is " + c.getArea());
    }
}
```

Question 2

- a. A class defines the attributes and methods of a particular object. When objects are created from this class they are called instances (or objects) for example a class may be 'Car' with instances being 'Ferrari' and 'McLaren'.
 - b. Polymorphism occurs when a method has different implementations with the same signature. As an example consider a class called 'Shapes'. From this class let the classes 'Circle' and 'Square' be generated. In Circle we can have a method called Area (double r) and in Square a method Area (double x). The program would know when to calculate the area of a circle or the area of a square.
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Question 3

$$\begin{aligned} & \textcircled{3} \quad \overline{C\bar{D} + A\bar{B}C + A\bar{B}\bar{C}} \\ &= \overline{C\bar{D} + (\bar{A} + A)\bar{B}C} \quad (\text{distributive law}) \\ &= \overline{C\bar{D} + \bar{B}C} \quad (\text{tautology ""}) \\ &= \overline{C\bar{D}} \cdot \overline{\bar{B}C} \quad (\text{De Morgan's ""}) \\ &= (\overline{C} + \overline{\bar{D}}) \cdot (\overline{\bar{B}} + \overline{\bar{C}}) \quad \text{" -} \\ &= (C + D)(B + C) \quad (\text{double negative law}) \\ &= CB + C\bar{C} + DB + DC \quad (\text{distributive law}) \\ &= CB + C + DB + DC \quad (\text{tautology law}) \\ &= C + DB \quad (\text{law of absorption}) \end{aligned}$$

Question 4

- a. 7 bits ($2^7 = 128$)
- b. '5' is 35H
- c. 'N' is 4EH

Question 5

When a peripheral wants to transfer data to RAM the system usually uses the DMA method. Another less efficient method is by using interrupts. In the latter method the CPU issues commands to the I/O module to write in RAM when the buffer is full. Each time the buffer is full the I/O module interrupts the CPU so that the data in the buffer can be sent to RAM. In the DMA system the I/O module seeks a one-time permission only to write for successive times the data from the buffer to RAM. It only informs the CPU when all the input data is written in the RAM.

Question 6

- a. An assembler is software that translates assembly language into machine language. A linker is a utility program that links a compiled or assembled

program with other methods (subroutines) from libraries. It produces executable code ready to run on the computer.

- b. A cross assembler generates machine language for a different type of computer than the one the assembler is running in. Very small microprocessors would not be capable of handling an assembler.

Question 7

21 instructions: the first two are executed once; the next three (loop) are executed 6 times; the last instruction is executed once.

Question 8

- a. A hash table is a lookup table that implements very efficiently random access. Hash tables are created by using a hashing function (algorithm) to produce the address of a record in the hash table. Since different keys may hash to the same address (called a collision), the goal of hash table design is to spread out the addresses evenly to avoid collisions. For efficient use of the hash table, collisions should be rare but in any case a collision policy should be found e.g. when a collision occurs the record is placed in the next empty space. When an item is looked up, its key is hashed to find the address it should be in. In case it is not found then it is searched according to the collision policy.
- b. For the best use of the hashing function the number of spaces in the hash table should be appropriate (too small would cause too many collisions and too large would be wasteful in memory). Also, the hashing function should be distributive i.e. it should produce addresses that span all the memory space, otherwise many collisions may occur.

Question 9

Five data dictionary components are the following: (*) Names of tables with their corresponding fields, types of fields and number of records in each table; (*) Macros; (*) Relationships; (*) Privileges e.g. read/modify etc.; (*) Information about indices.

Question 10

- a.

title	Pub_date
Curry	2010-07-14
Team Canada 1972	2012-09-13

b.

title	quantity
Surfing: a Beginner's Guide	0
Data Structures and Algorithms	5
Grey's Land: The Alien Agenda	3
Elvis Impersonation Kit	1000

Question 11

- a. The choice of an operating system depends primarily on the applications that one will be using. For a personal computer one will normally choose a multitasking OS. For bigger applications, like an airline reservation system on a network, one would need a soft real-time OS. For a control system managing a nuclear plant OS must obviously be hard real-time.
- b. Real-time, multi-tasking, network OS.
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Question 12

- a. (i) Protect files against unauthorised access to maintain confidentiality; (ii) protect files against loss of data (by backups) to maintain data integrity.
- b. Passwords, encryption, firewall.
-

Question 13

- a. The purpose of interrupt handling is to let slow devices, like the printer, interrupt the processor so that they can get their work done. When the processor receives an interrupt, e.g. that the mouse has been moved, the processor calls a special program associated with the interrupt, called an interrupt handler, and this program performs processing as necessitated by the device. When the interrupt handler finishes executing the processor can proceed with the interrupted program.
- b. Process management, memory management, user interface.
-

Question 14

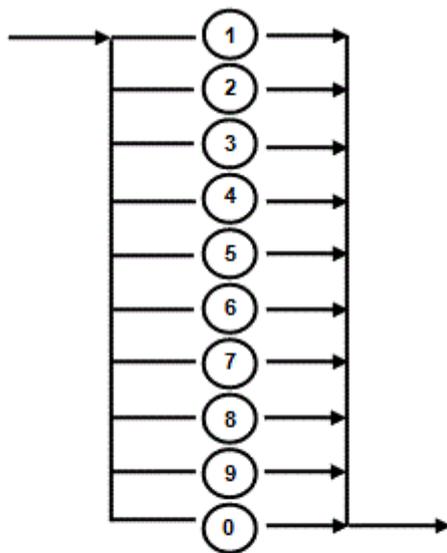
- a. Error checking is important because the receiver must have a way to check whether the received information is correct. Recovery is important because it makes communication reliable.
- b. Single parity checking, block parity checking, CRC.
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Question 15

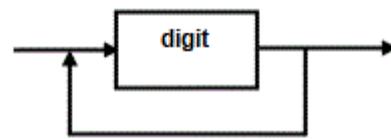
- a. Modulation
-

Question 16

- a. A syntax diagram is a diagrammatic way to represent the grammatical rules of a computer language.
- b. It can be used to represent a HLL because a HLL is a context-free language i.e. there is no ambiguity.
- c.



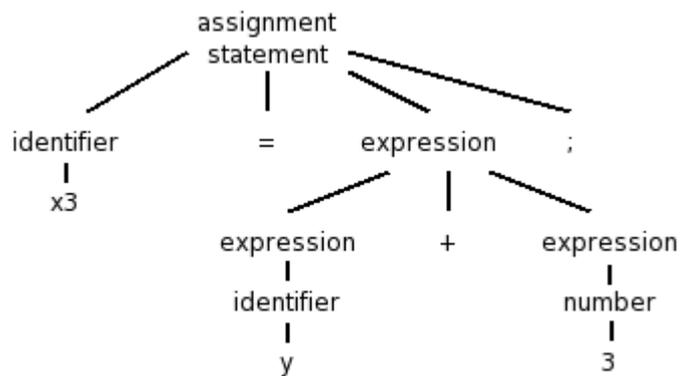
Syntax diagram of a digit



Syntax diagram of an unsigned integer

Question 17

- a. A parse tree is a diagram in form of a tree that shows the derivation of a statement following the language grammar. The tree on the right is an example of a parse tree.
- b. Both a syntax diagram and BNF notation define the grammar of a programming



language. The syntax diagram is pictorial while the BNF notation is based on production rules. An example of a syntax diagram is found in question 16. The following is a BNF definition for an unsigned integer:

$$\begin{aligned} \langle \text{digit} \rangle &::= 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 \\ \langle \text{unsigned integer} \rangle &::= \langle \text{digit} \rangle | \langle \text{unsigned integer} \rangle \langle \text{digit} \rangle \end{aligned}$$

- c. A non-terminal symbol does not form part of the vocabulary of a language. It is simply used in the process of producing valid statements of a language. A terminal symbol forms part of the vocabulary of a language. In the above example 0, 1, 2 etc. are terminals while $\langle \text{unsigned integer} \rangle$ and $\langle \text{digit} \rangle$ are non-terminals.
-

Question 18

- a.
- i. $o = A^B * C - 6$
 - ii. $= o^* AB - C 6$
 - iii. $o AB^A C 6 - * =$
- b. Usually the postfix notation is used because it is easy to calculate such an expression (where a stack is used).
-

Question 19

- a. The first two stages are (i) feasibility study, and (ii) system's analysis.
- b. The last stage of the SDLC is maintenance. There are different types of maintenance e.g. perfective maintenance where the system is improved (e.g. database response to queries made faster). There is adaptive maintenance where changes are required (e.g. new government legislation may mean that new methods of calculating tax are required); corrective maintenance means correcting problems, like software bugs, encountered in the new system; predictive maintenance implies the use of techniques that help determine the condition of the equipment in order to predict when maintenance should be performed.
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Question 20

The requirements phase is the initial phase of the development process wherein the development team works closely with the customer to determine the customer's requirements for the product. Basically in the waterfall model the systems analyst gathers information through interviews, questionnaires and other similar means. In the RAD model information gathering is made through seminar meetings with large groups – in a day or a weekend or more depending on the size of the project. Users, managers, and IT staff members discuss and agree on

business needs, project scope, constraints, and system requirements. The seminar ends when the team agrees on the key issues and obtains management authorization.

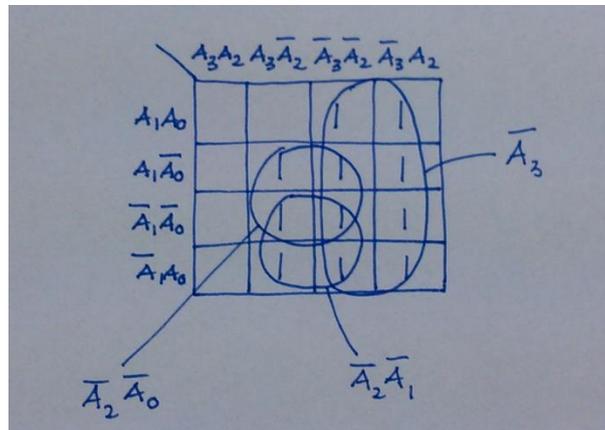
Paper 2

Question 1

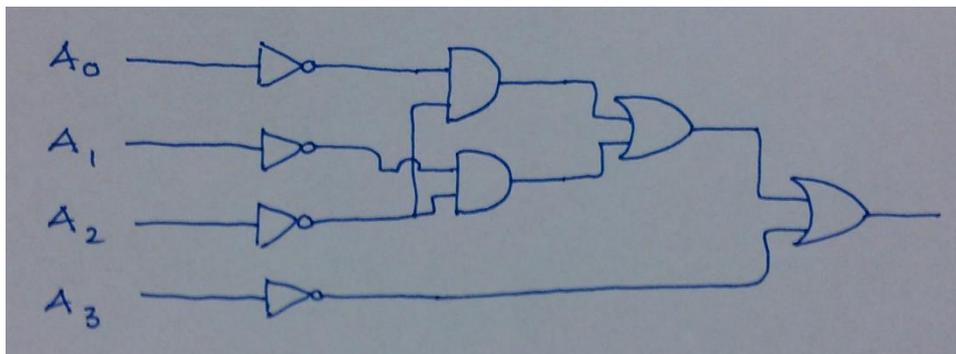
- a. Maximum value is 1111_2 . This is equal to 15_{10} .
- b.

A_3	A_2	A_1	A_0	F
0	0	0	0	1
0	0	0	1	1
0	0	1	0	1
0	0	1	1	1
0	1	0	0	1
0	1	0	1	1
0	1	1	0	1
0	1	1	1	1
1	0	0	0	1
1	0	0	1	1
1	0	1	0	1
1	0	1	1	1
1	1	0	0	0
1	1	0	1	0
1	1	1	0	0
1	1	1	1	0

- c. Karnaugh map:



- d.



- e. By observing the Karnaugh map in (c), adding a 1 for $A_3\overline{A_2}A_1A_0$ would produce $\overline{A_2} + \overline{A_3}$.
- f. When A_0 is 0 A is even, otherwise it is odd.
-

Question 2

- a. $2^{28} = 2^8 \times 2^{20} = 256 \times 2^{20}$ locations = 256 M = 0.25 G = 268,435,456 locations.
- b. MAR and MDR are two registers found inside the CPU. Whenever the CPU requires sending an address to RAM it does so by placing the address in the MAR. This address will eventually be carried to RAM by means of the address bus. MDR has a similar function but it is reserved for data. Data is carried to RAM by the data bus. MDR is also used to receive data from RAM. Whenever RAM sends data to the CPU this data is first carried by the data bus and then it is deposited in the MDR.
- c. DRAM is slower than SRAM. They are both volatile. DRAM is less expensive than SRAM as each bit is made up of fewer components. However it needs to be refreshed thousands of times per second to maintain the information it holds. This makes it slower in its 'read' and 'write' operations.
- d. DRAM is used as the computer's RAM while SRAM is used as cache.
- e. Addressing modes (immediate, direct, indirect and others) refer to instructions in assembly language which involve placing data inside registers. In 'immediate addressing' the data is found inside the instruction itself, for example 'LDA #12' means 'load 12 into A (the accumulator)'. In 'direct addressing' the instruction holds the memory address which holds the required data, for example 'LDA 523' means 'load the contents of address 523 into A'. In 'indirect addressing' the operand in the instruction is an address and at this address is found another address which holds the value required e.g. LDA [523] means 'load the contents found in the address found in address 523'.
-

Question 3

- a.
- i. Airline reservation system. This is a soft real-time application. The response time of the application to a user's request is guaranteed to be below a time limit of a few seconds. The system is built in such a way as to be able to handle a given (usually thousands) of requests per second.
 - ii. Process control system e.g. auto-pilot. This is a hard real-time application. Response time by the system is crucial as failure can cause a disaster. For this reason the system is implemented to be fault tolerant. This is achieved by duplicating components and software.

- Programs, written by different programs, run in parallel and their outputs are matched.
- iii. Transaction processing e.g. internet banking. This is a soft real-time application. Transactions are executed in real-time as amounts of money pass from one account to another at the end of the transactions.
- b. Reliability in terms of response time is crucial in hard real-time systems. This is achieved, as already mentioned, by duplication of components. Failure of a component will not compromise the running of the system. Reliability can be interpreted also in terms of processing integrity i.e. being sure that the processing is correctly done. In hard real-time systems cost is much increased because of the purchase of redundant components and because the software is given more testing (e.g. white box instead of black box). Bugs in hard real-time systems can be catastrophic.
-

Question 4

- a. Modulation is a process that receives a wave (analogue or digital) and then performs temporary changes in a carrier wave so that the original wave can be transported over the carrier wave. Upon arrival de-modulation occurs.
- b. Four modulation techniques are the following:
 - i. Amplitude modulation
 - The amplitude of the carrier wave is changed to reflect the changes of the original wave.
 - Since noise on telephone lines might be confused with data AM was not ordinarily used by modems.
 - ii. Frequency modulation
 - The frequency of the carrier wave is changed to reflect the fluctuations of the original wave.
 - FM is widely used in audio transmission.
 - FM is immune to noise. This makes it a more reliable transmission method for modems.
 - iii. Phase modulation
 - The fluctuations of the original wave are expressed as variations in the phase of a carrier wave.
 - PM is not widely used for transmitting radio waves. This is because PM requires more complex receiving hardware, and there can be ambiguity problems in determining whether, for example, the signal has changed phase by $+180^\circ$ or -180° .
 - iv. Pulse-code modulation

- In PCM the modulating signal follows the following transformations:
 - (i) it is first sampled, (ii) the resulting signals are then quantized,
 - (iii) each quantized level is then represented by a sequence of pulses known as a code.
-

Question 5

- a. Compilation refers to the process of translating a program from a high level language to object code. Since a program is often made up of a number of modules these modules have to be linked together to form one whole program. This linking is performed by a program called the linker. If a module contains a syntactic error the error will not compile it. Some compilers do not just translate but also perform optimization i.e. they improve the code (in terms of speed of execution). Compilers come in various types e.g. just-in-time compiler or cross compiler. Linking can be static or dynamic. Static linking is the process of copying all library modules used in the program into the final executable image. This is performed by the linker and it is done as the last step of the compilation process. In dynamic linking the names of the external libraries (shared libraries) are placed in the final executable file while the actual linking takes place at run time when both executable file and libraries are placed in the memory. Dynamic linking lets several programs use a single copy of an executable module.
- b. Suppose that you have the following program (here shown in pseudocode):

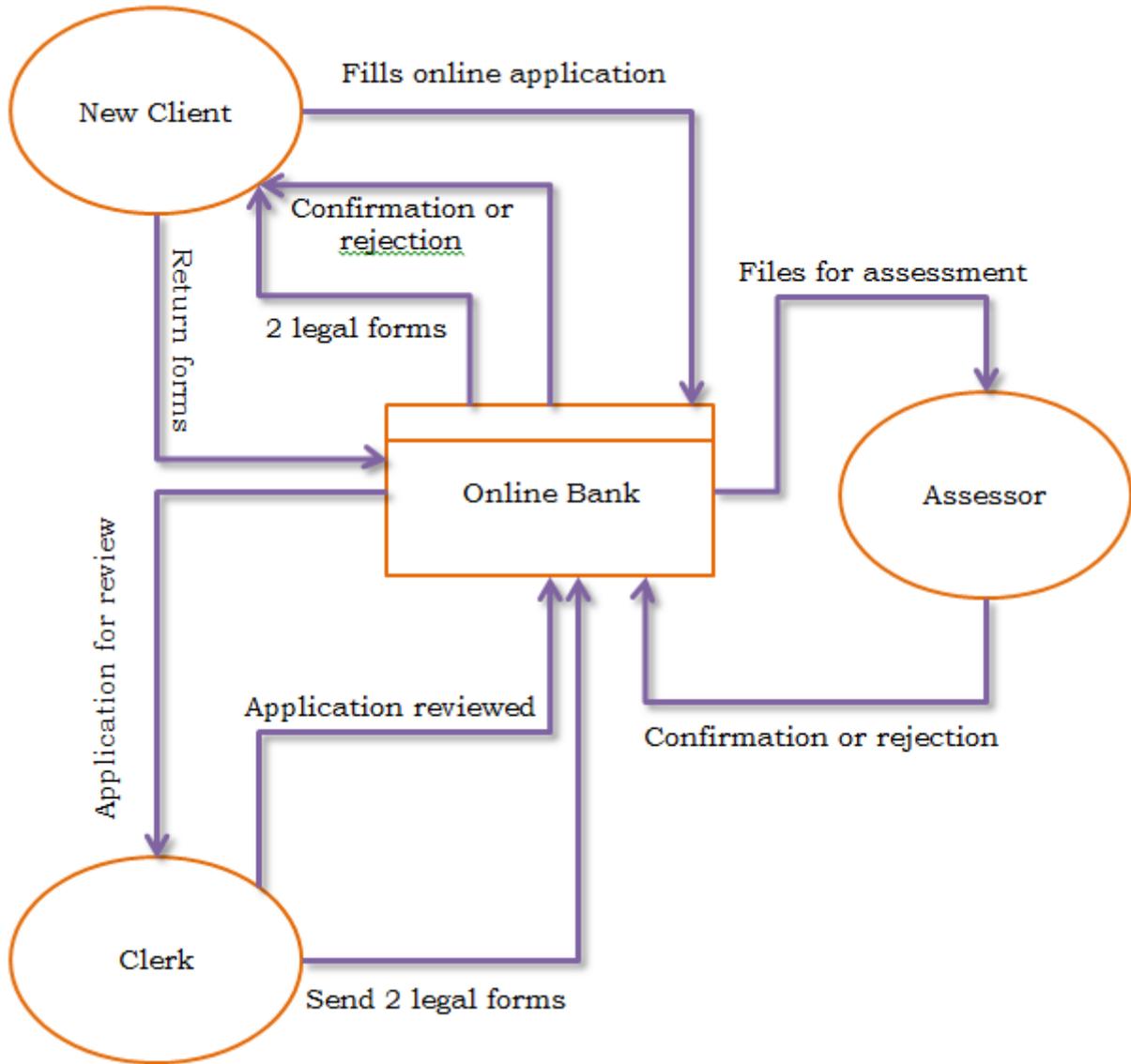
```
begin
  import library1
  import library2
  statement1
  call method abc from library1
  statement2
  call method xyz from library2
  statement3
end
```

I will use this example to show how static compilation works. The compiler will translate statement1, statement2 and statement3 in object code. Then the linker will copy abc (in object code) from library1 and insert it after the translation of statement1. Likewise it will copy xyz from library 2 and insert it after statement2.

- c. The programmer uses a linker (indirectly) because it is very convenient to make use of libraries. This has the advantage of code re-use. When linking is dynamic there is the added advantage that the programs are not large. Linking will be done during execution and the object code need not have imported methods embedded in itself.
-

Question 6

a.



- d. In Java exceptions are handled using the 'try' and 'catch' structure. In the 'try' part the code for execution is written while in the 'catch' part code is written such that it will be executed in case an exception occurs. In the following code the program would not crash if the correct type of input is not entered.

```
try
{
    System.out.print ("Enter a number:");
    int number = input.nextInt();
}
catch (InputMismatchException ex)
{
    System.out.println ("Invalid input");
}
```

- e. The main difference between a linked list and an array is that a linked list has sequential access and an array has direct access. If we have a sorted array then a binary search can be used and this is much faster than the linear search. In the case of a linked list we have no choice but to use the linear search. With insertions however the linked list is in an advantageous position over the array. In the array an insertion would cause many shifts of values to make space for the inserted element. This does not happen in the linked list. An insertion caused very little processing. Besides, an array is a static data structure (if it is full you cannot add more elements) while the linear list is dynamic i.e. it is never full and it can be extended indefinitely.

Question 8

a.

BOOKS

bookID	typeID	quantity	price
1	1	0	25.99
2	2	1	12.99
3	2	4	15.99
4	3	3	9.99
5	2	1	4.99

TYPES

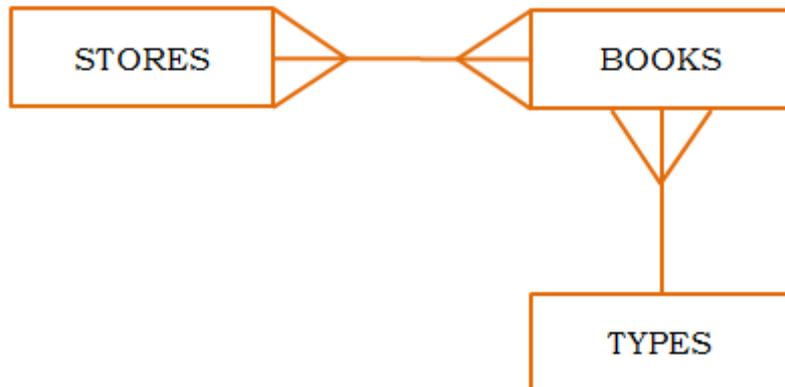
typeID	type
1	Cooking
2	Travel
3	Sports

Primary keys are bookID for BOOKS and typeID for TYPES.

- b. One risk would be data inconsistency. In one tuple we would enter, for example, that typeID 1 is Cooking and in another that typeID 1 is Sports.
- c. No because bookID is unique so a book can only appear once in the table.

d.

- i. The following entity relationship diagram shows how the new database could be organized.



To implement the many-to-many relationship between STORES and BOOKS we need to define another table. Let us call this STORES_BOOKS. The new entity relationship diagram will look as follows.



- ii. The attributes will be as follows:

STORES (StoreID, Address)

STORE_BOOKS (StoreID, BookID, Quantity, Price)

BOOKS (BookID, TypeID)

TYPES (TypeID, Type)