21st International Microelectronics Olympiad

T E S T

The participants shall select one answer out of 5 possible answers in the answer sheet for each question (A, B, C, D, E) by crossing lines from the top left corner to the bottom right corner and form the bottom left corner to the top right corner (as it is shown below).

8.	A	B	C	D	E

In the case of crossing out more than one answer for the same question or making any other notes, the answer to that question will be scored 0.

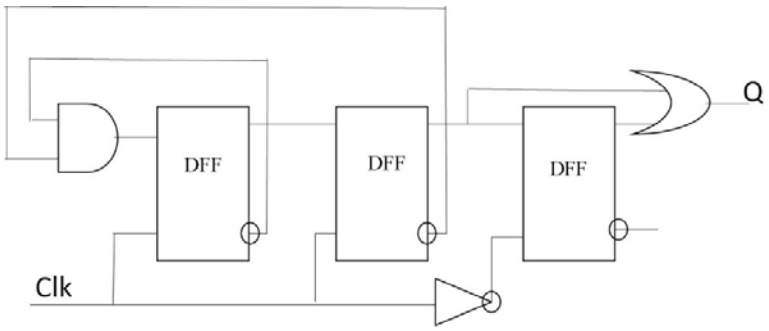
8.	A	B	C	D	E

Participant _____

University _____

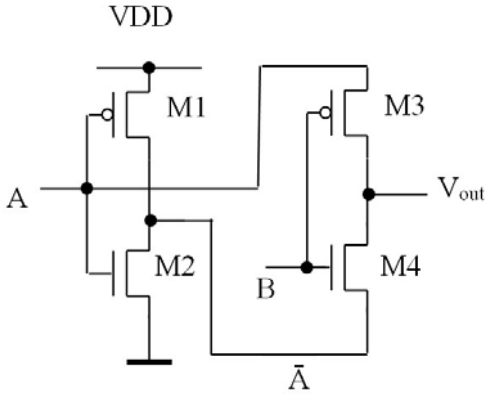
1. What will be the output frequency if the input clock signal is 3600MHz?

A. 800
B. 1700
C. 2000
D. 1200
E. 7200



2. What logic function is implemented by the circuit shown in the figure?

A. OR
B. XNOR
C. XOR
D. NAND
E. NOR



3. The value of the threshold voltage Vth of the short-channel transistor compared to the long-channel MOS transistor depends on:

A. L channel length
B. W channel width
C. V_{DS} drain voltage
D. Channel length, width and drain's V_{DS} voltage
E. All the answers are correct

4. The following is not operating domain of $I_{DS} = f(V_{DS})$ characteristic of a MOS transistor with induced channel:

A. Linear domain
B. Saturation domain
C. Cut-off domain
D. Breakdown domain
E. Linear and saturation domains

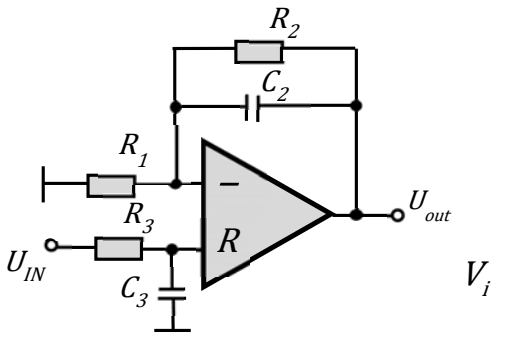
5. Which of the following digital devices can determine which of the two codes is larger?

A. Encoder
B. Decoder
C. Multiplexer
D. Comparator
E. Distributor

6. Which of the given graphs gives the possibility of describing multi-branch chains?

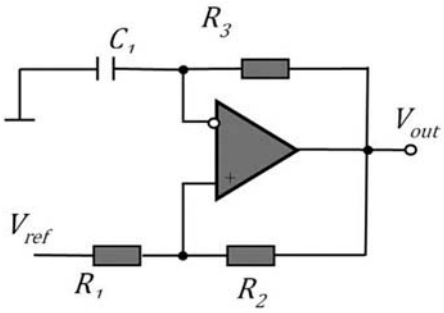
A. Directed graph
B. Acyclic graph
C. Hypergraph
D. Multigraph
E. Not-linked graph

7. What function can be implemented by this circuit?



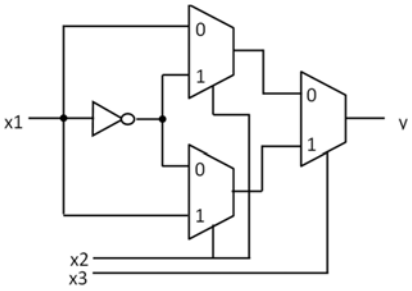
A. Second-order high-pass filter
B. Layer filter
C. Blocking (rejector) filter
D. Second order low-pass filter
E. All the answers are wrong

8. What function can be implemented by this circuit?



A. High frequency filter - amplifier
B. Sinusoidal signal generator
C. Rectangular pulse generator
D. Low-pass filter-amplifier
E. All the answers are wrong

9. Determine what function is implemented by this circuit.



A. y=x1⊕x2⊕~x3
B. y=x1⊕x2⊕x3
C. y=x1⊕~x2⊕x3
D. ~x1⊕x2⊕x3
E. No correct answer

10. What values will be set in the following flags when adding two signed 8-bit numbers 45 and -45.
CF - carry flag, ZF - zero flag, SF - sign flag, PF - parity flag, OF-overflow flag

A. CF = 0, ZF =0, OF =1, SF = 1, PF =0
B. CF = 0, ZF =1, OF =1, SF = 1, PF =0
C. CF =1, ZF =1, OF =0, SF = 0, PF =1
D. CF =1, ZF =1, OF =0, SF = 1, PF =1
E. No correct answer

11. How many different roots does the following equation have?

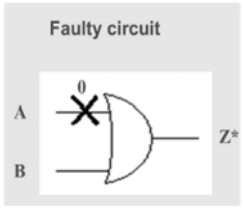
$$\begin{vmatrix} x & 1 & 2 & 3 & \dots & 2022 \\ 1 & x & 2 & 3 & \dots & 2022 \\ 1 & 2 & x & 3 & \dots & 2022 \\ 1 & 2 & 3 & x & \dots & 2022 \\ \dots & \dots & \dots & \dots & \dots & \dots \\ 1 & 2 & 3 & 4 & \dots & x \end{vmatrix} = 0$$

A. 1
B. 2023
C. 2022
D. 2021
E. 2020

12. Evaluate $\lim_{n\to\infty} n\int_0^1 x^n e^{5x-3x^2}\,dx$

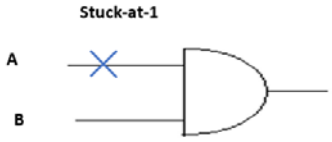
A. 1
B. e
C. e^2
D. e^3
E. e^4

13. Consider the simple OR gate with input lines A and B. The input line A has a single stuck-at-0 fault. Find the correct answer among the 5 statements below:



A. The fault "A stuck-at-0" is undetectable
B. Input vector (A,B)=(0,0) is a test for detection of the fault "A s-a-0"
C. Input vector (A,B)=(0,1) is a test for detection of the fault "A s-a-0"
D. Input vector (A,B)=(1,0) is a test for detection of the fault "A s-a-0"
E. Input vector (A,B)=(1,1) is a test for detection of the fault "A s-a-0"

14. Consider the simple AND gate with input lines A and B. Among the 5 statements listed below, choose the correct answer:



A. The fault "A stuck-at-1" is not detectable
B. The input pattern (A,B)=(0,0) is a test detecting the fault "A stuck-at-1"
C. The input pattern (A,B)=(0,1) is a test detecting the fault "A stuck-at-1"
D. The input pattern (A,B)=(1,0) is a test detecting the fault "A stuck-at-1"
E. The input pattern (A,B)=(1,1) is a test detecting the fault "A stuck-at-1"

15. Why does the resistance of a semiconductor drop with increasing temperature?
A. Because the number of free charge carriers decreases
B. Because the number of free charge carriers increases
C. Because the work function of electrons decreases
D. Because the band gap increases
E. Because the number of surface states decreases

16. Why does the resistance decrease when it is illuminated?
A. Because the light reflects off the surface of the semiconductor
B. Because illumination generates free charge carriers
C. Because the illumination is not absorbed in the bulk of the semiconductor
D. Because the energy of the absorbed photons is less than the band gap
E. Because the illumination passes through the semiconductor without absorption

17. Which formula is the correct formula for common-mode gain?
A. $g_m R_D$
B. $\frac{g_m R_S}{1+(g_m+g_{mb})R_S}$
C. $\frac{-g_m R_D}{1+g_m R_S}$
D. $-g_m R_D$
E. $-\frac{R_D/2}{1/(2g_m)+R_{SS}}$

18. What statement is correct about common source amplifier with source degeneration?

A. It has bigger gain than without degeneration version
B. Linearity of amplifier is bigger compared with without degeneration version
C. It will result to phase shift from input to output to be 360 degrees
D. Output voltage swing will increase compared with without degeneration version
E. Power consumption will increase compared with without degeneration version

19. What will be the output of the following code?

```
{
   int k = 8;
   int x = 0 == 1 && k++;
   printf ("%d%d\n", x, k);
}
```

A. 0 9
B. 0 8
C. 1 8
D. 1 9
E. 21

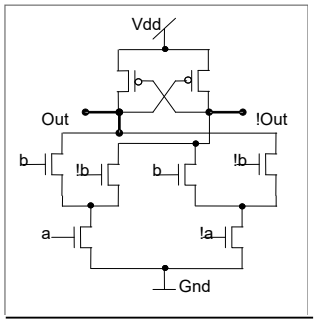
20. What is the time complexity of the following code?

```
int i = 1, s =1;
while (s <= n)
{
   i++;
   s += i;
}
```

A. O (n)
B. O (log)
C. O (√n)
D. O (nlogn)
E. No correct answer

21. What logic function is implemented by the presented circuit?

A. AND
B. XOR-XNOR
C. AND-NAND
D. OR-NOR
E. MUX-MUXI

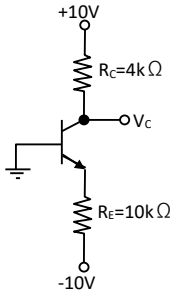


22. Which is the Canonical Disjunctive Normal Form (CDNF) of the function described by the following truth table?

Inputs			Output
a	b	c	y
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	1

A. y=!a&b&!c+!a&b&c+a&b&!c+a&b&c
B. y=!a&!b&!c+!a&!b&c+a&!b&!c+a&!b&c
C. y=(a+b+c)&(a+b+!c)&(!a+b+c)&(!a+b+!c)
D. y=(!a+!b+!c)&(!a+!b+c)&(a+!b+!c)&(a+!b+c)
E. y=(a+!b+c)&(a+!b+!c)&(!a+!b+c)&(!a+!b+!c)

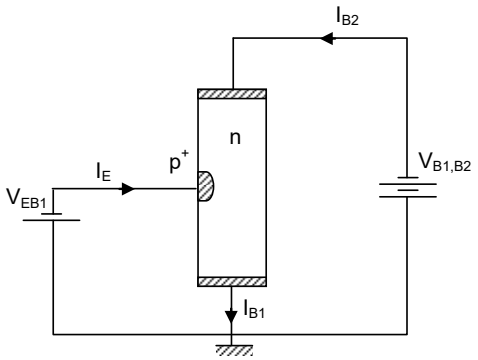
23. In the operation of a typical active-mode BJT transistor, the topology opposite is:



A. A common-base connection
B. A common-emitter connection
C. A common-collector connection
D. A common-base and common-emitter connection
E. None of the above

24. What is the reason for the occurrence of negative differential conductance region on the emitter current I_e dependence on base voltage V_{EB1} in case of a single junction transistor?

A. P + - n-junction breakdown
B. Strong injection of holes into base
C. Electron injection from ohmic B1- contact
D. Impact ionization phenomena in the base
E. A. and C. answers are correct



25. A password must contain 2 numerals from the list {0, 1, 2, 3, 4, 5, 6, 7, 8, 9} and 2 letters from the list {a, A, b, B, c, C, d, D, e, E}. The first symbol must be a letter. Symbols may be repetitive. How many passwords can be generated meeting those conditions?

A. 100 000
B. 400 000
C. 600 000
D. 800 000
E. 1 000 000

26. Which of the following sets of functions is not qualified as overloaded function?

*A. void fun(int, char *)*
*void fun(char *, int)*
B. void x(int, char)
*int *x(int, char)*
C. int get(int)
int get(int, int)
*D. void F(int *)*
*void F(float *)*
E. All of the above are overloaded functions

Answer Sheet

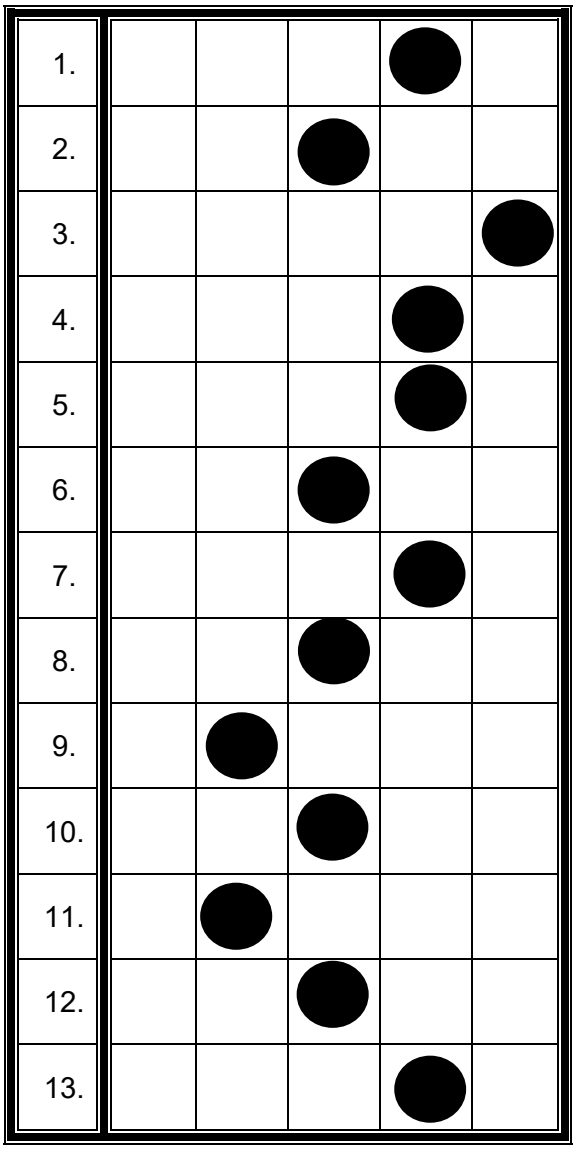
1.	A	B	C	D	E
2.	A	B	C	D	E
3.	A	B	C	D	E
4.	A	B	C	D	E
5.	A	B	C	D	E
6.	A	B	C	D	E
7.	A	B	C	D	E
8.	A	B	C	D	E
9.	A	B	C	D	E
10.	A	B	C	D	E
11.	A	B	C	D	E
12.	A	B	C	D	E
13.	A	B	C	D	E

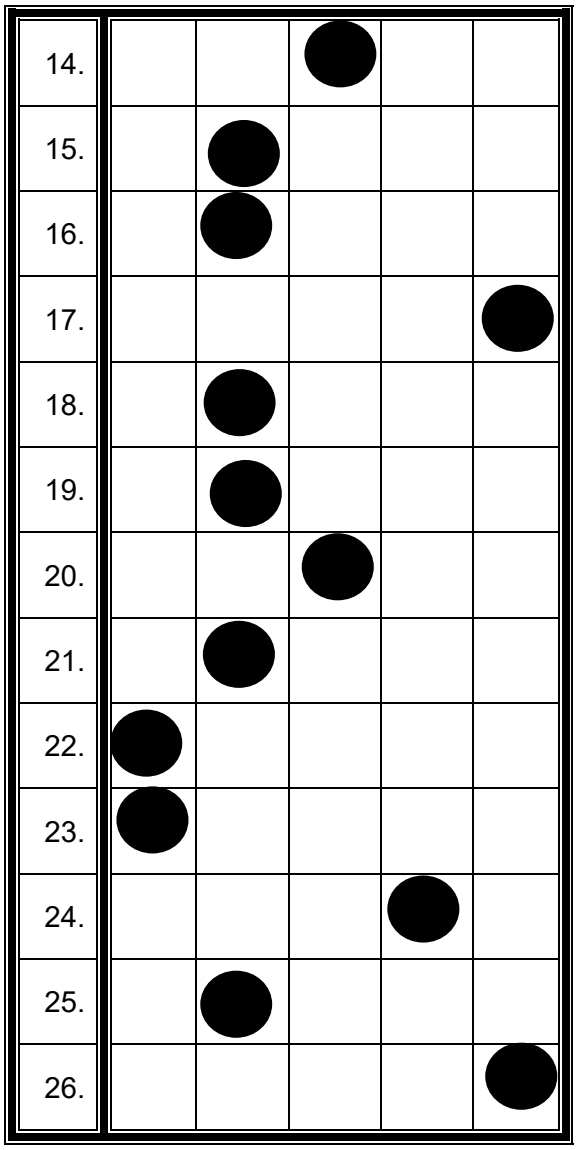
14.	A	B	C	D	E
15.	A	B	C	D	E
16.	A	B	C	D	E
17.	A	B	C	D	E
18.	A	B	C	D	E
19.	A	B	C	D	E
20.	A	B	C	D	E
21.	A	B	C	D	E
22.	A	B	C	D	E
23.	A	B	C	D	E
24.	A	B	C	D	E
25.	A	B	C	D	E
26.	A	B	C	D	E

Student _____

University _____

Answer Sheet





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ADDITIONAL T E S T

The participants shall select one answer out of 5 possible answers in the answer sheet for each question (A, B, C, D, E) by crossing lines from the top left corner to the bottom right corner and form the bottom left corner to the top right corner (as it is shown below).

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In the case of crossing out more than one answer for the same question or making any other notes, the answer to that question will be scored 0.

8.	A	B	C	D	E

Participant _____

1. Which is the basic consequence of MOS transistor's degradation due to warm carriers?

A. *The increase of threshold voltage*
B. *The decrease of threshold voltage*
C. *The increase of channel resistance*
D. *The decrease of channel resistance*
E. *The decrease of drain-package disruption voltage*

2. C capacitance is connected to the end of interconnect line with L length, line parameters are c [F/m], r [Ohm/m]. By what formula is the signal delay time in the line given?

A. *0.7rc*
B. *0.7Lr(C+c)*
C. *0.7Lr(C+Lc/2)*
D. *0.7Lr(C+Lc)*
E. *0.7Lr(C/2+Lc/2)*

3. Denote by $\mathfrak{ф}$ the set of all possible single stuck-at-0 and stuck-at-1 faults on input and output lines of logical V ("OR"), & ("AND") ^("NOT"). For any fault $F \in \mathfrak{ф}$, denote by T(F) the set of all input ("test") patterns detecting F. It is said for any two faults Fi, Fj $\in \mathfrak{ф}$ that "fault Fi dominates fault Fj if:

A. $T(Fi) \cap T(Fj) = \varnothing$
B. $T(Fi) = T(Fj)$
C. $T(Fi) \subseteq T(Fj)$
D. $T(Fj) \subseteq T(Fi)$
E. *The correct answer is missing*

4. Which function corresponds to the following polynomial y= 1 ⊕x1⊕ x1·x2 ⊕ x3?

A. $y= \bar{x1}\cdot \bar{x3} + x2\cdot \bar{x3} + x1\cdot \bar{x2}\cdot x3$
B. $y= \bar{x1}\cdot \bar{x3} + x2\cdot \bar{x3} + x1\cdot x3$
C. $y= \bar{x1}\cdot \bar{x2} + x2\cdot \bar{x3} + x1\cdot x3$
D. $y= x1\cdot \bar{x2}\cdot x3 + x2\cdot \bar{x3} + x1\cdot \bar{x3}$
E. *The correct answer is missing*

5. What is the vibration, occurring due to supply voltage noise, called?

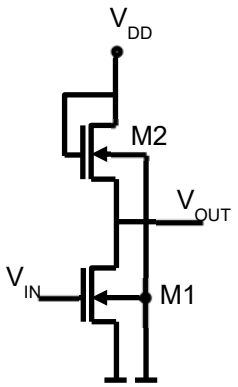
A. *Simply vibration, does not have certain name*
B. *Deterministic*
C. *Non-deterministic*
D. *Random*
E. *Supply voltage vibration*

6. The volt-ampere characteristics of the semiconductor p-n junction is:

A. *Linear*
B. *Highly nonlinear*

C. *Direct current is smaller than reverse current*
D. *Reverse current is larger than direct current*
E. *Does not depend on temperature.*

7. How will the small signal amplification coefficient of an amplifier change if the channel width of M1 transistor is shared?



A. *It is shared, too*
B. *It doubles*
C. *It becomes a little less than half*
D. *It increases by more than 2 times*
E. *It becomes a little more than half*

8. Breakdown mechanisms of semiconductor p-n junction are:

A. *Avalanche*
B. *Tunnel*
C. *Thermal*
D. *Electrical*
E. *All the answers are correct*

9. By ion doping method, the depth of p-n junction that is formed in semiconductor crystal volume, depends on:

A. *Accelerated ion energy*
B. *Semiconductor crystallographic orientation*
C. *Accelerated ion type*
D. *Initial concentration of impurities in a crystal*
E. *All the answers are correct*

10. The depth of p-n junction that is formed by ion doping method, depends on:

A. *Accelerated ion energy and type*
B. *Ion beam dose*
C. *Only accelerated ion type*
D. *Ion current density*

E. *Only crystal temperature*

11. The function $f(x)=\cos x$ is replaced by the interpolating polynomial L_3 by equidistant nodes (i.e. third order polynomial, what have the values $y_k=\cos\frac{k}{n}b$ in the points $x_k=\frac{k}{n}b$, $k=0,1,2,3$) on the interval [0, b]. Find the value of b, such that the error does not exceed 10^{-3}.

A. *1,5*
B. *1,4*
C. *1,3*
D. *1,2*
E. *1,1*

12. Which of the mentioned parameters is fixed for all cells of the given Standard Cell Library?

A. *Supply voltage*
B. *Area*
C. *Cell length*
D. *Input capacitance of the cell*
E. *Output capacitance of the cell*

13. During IC design, which is maintained constant?

A. *Cell dimensions*
B. *Preparation technology*
C. *Interconnects width*
D. *The number of metal layers*
E. *Area*

14. Which of the following parameters is characterized by an electrical short or long connection lines difference?

A. *Load capacitance*
B. *Signal power*
C. *Signal frequency*
D. *Interconnect width*
E. *A. and B.*

15. The code below is aimed to shift the values in the array data to the left, so that if original array is

1	6	8	1	15	2

After the code execution the array will contain the following:

6	8	1	15	2	1

There are two lines of code missing in this program line1 and line2. Which lines should be placed instead of line1 and line2 for the code to work? (n=6, which is the number of elements in data array)

```
//line1
for (int i = 0; i < n - 1; i++)
{
    data[i] = data[i + 1];
}
//line2
```

A.

```
    //line1
    temp = data[0];
   //line2
   data[0] = temp;
```

B.

```
   //line1
   temp = data[0];
   //line2
   data[n - 1] = temp;
```

C.

```
   //line1
   temp = data[n - 1];
   //line2
   data[0] = temp;
```

D.

```
   //line1
```

```
temp = data[n - 1];
//line2
data[0] = temp;
```

E.

```
//line1
temp = data[n - 2];
//line2
data[n - 1] = temp;
```

Additional Test Answer Sheet

1.	A	B	C	D	E
2.	A	B	C	D	E
3.	A	B	C	D	E
4.	A	B	C	D	E
5.	A	B	C	D	E
6.	A	B	C	D	E
7.	A	B	C	D	E
8.	A	B	C	D	E
9.	A	B	C	D	E
10.	A	B	C	D	E
11.	A	B	C	D	E
12.	A	B	C	D	E
13.	A	B	C	D	E
14.	A	B	C	D	E
15.	A	B	C	D	E

Participant _____

Additional Test Answer Sheet