The exam consists of 30 multiple choice questions. For each question you are asked to select a single answer, i.e. the best / most complete answer. Each question is worth 1 point.

INSTRUCTIONS
- You MUST fill in the fields Last name, First name, cs login, Purdue ID, Recitation section in the header above, and put your signature. For Recitation section, find your recitation section in the table below and put in the value in last column of the table below

Remember to fill in the following bubble sheet fields:
- student ID: use the 10 digit ID number on your student ID card. **DO NOT USE YOUR SOCIAL SECURITY NUMBER**!
- Last Name and First Name
- Instructor: put your RECITATION INSTRUCTOR’S LAST NAME given in the table below
- Test/Quiz: put 03
- Course: 177
- Section number: find your recitation section in the table below and put in the bubble card the last column of the table below
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<th>Recitation Section</th>
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1. How many bits per value do you need to encode the age of humans, as an integer number of years, knowing that no one is older than 127?

A. 127  
B. 200  
C. 4  
*D. 7  
E. none of the above

2. Which of the following statements is true?

A. 100 in base 16 equals 100 in base 10  
B. 100 in base 16 is less than 100 in base 10  
*C. 100 in base 16 is greater than 100 in base 10

3. What is a good data structure for storing a digital picture?

A. A linked list  
B. A binary tree  
*C. A 2-D array  
D. A graph  
E. All of the above
4. A binary tree has \( n \) nodes on level \( k \) and \( m \) nodes on the deeper level \( k+1 \). Deeper means farther from the root.

A. \( m \) is always greater than \( n \), for any binary tree and for any level \( k \)

*B. It could happen that \( m < n \), depending on the binary tree and the level \( k \)

C. If \( m < n \) the data structure is not a tree

D. \( m \) is always equal to \( n^2 \), for any binary tree and for any level \( k \)

E. A and D

5. The adjacency matrix representation of an undirected graph with 5 nodes contains 0's on the main diagonal and 1's everywhere else.

A. There is an edge between any two nodes.

B. That is an invalid configuration.

C. If nodes represent cities and edges direct flights, then there is a direct flight between any two cities.

*D. A and C

E. None of the above

6. A 3-D array stores a CT scan in 1GB. The slices are 1mm apart, and each slice has 1mm \( \times \) 1mm pixels. What is the new array size in GB if the CT scan resolution is changed to slices 0.1mm apart and to 0.1mm \( \times \) 0.1mm pixels?

A. 0.001GB

B. 0.01GB

C. 100GB

*D. 1,000GB

E. None of the above
7. A linked list stores credit card transactions in ascending order. A linked list node stores a transaction value and a link to the next node. You are asked to insert a new node $Y$, and you have found that it needs to go after node $X$. What operations are needed:

A. $X->\text{next} = Y$
   $Y->\text{next} = X->\text{next}$

*B. $Y->\text{next} = X->\text{next}$
   $X->\text{next} = Y$

C. $X = Y->\text{prev}$
   $Y = X->\text{next}$

D. $X->\text{next} = Y->\text{next}$

E. None of the above
8. What is the value of the expression stored by the following binary tree?

A. 6
B. 9
C. 18
D. 36
E. 1
Given the following adjacency matrix encoding a directed graph, what is the shortest path from node 1 to node 6. The length of a path is the number of edges defining the path. If there is no path between two nodes, the length of the path is said to be infinity. Recall that, for example, a value of 1 on row 2 and column 0 means that there is an edge from node 2 to node 0.

```
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</tbody>
</table>
```

A. 0  
B. 1  
*C. 2*  
D. 3  
E. infinity
10. What does the following algorithm do:

**Input:**
- \( A \) // array of integers
- \( n \) // number of elements in array (array size)

**Output:**
- \( \text{Val} \) // ………………………………………………………….

\[ 
\text{Alg}(A, n) \\
\text{Val} = -1 \\
\text{for} \ i = 0 \text{ to } n-1 \\
\quad \text{if } A[i] < 0 \text{ then} \\
\quad \quad \text{continue} \\
\quad \text{endif} \\
\quad \text{if } \text{Val} == -1 \text{ or } \text{Val} > A[i] \text{ then} \\
\quad \quad \text{Val} = A[i] \\
\quad \text{endif} \\
\text{endfor} \\
\text{return } \text{Val} \\
\text{endAlg} 
\]

A. It returns the largest element of the array.
B. It returns the smallest element of the array.
C. It returns the largest non-negative array element, and -1 if all array elements are negative.
D. It returns the largest array element that is smaller than -1.
*E. It returns the smallest non-negative array element, and -1 if all array elements are negative.

11. What is the running time of the 2-D convolution algorithm for an image of size \( w \times h \) and a kernel of size \( k \times k \)?

A. \( w+h+k+k \)
B. \( w \times h \times k \)
*C. \( w \times h \times k \times k \)
D. \( w \times h \)
E. None of the above
12. Sub-algorithms:

A. Are used by a main algorithm to solve a sub-problem of the main problem.
B. Are only useful if the same sub-problem has to be solved for multiple input values.
C. Allow one to easily upgrade the solution for a sub-problem without modifying the main algorithm.
D. A, B, and C
E. A and C
13. What is wrong with the following recursive algorithm for counting the nodes of a binary tree?

Input:
   T // link to root of binary tree
Output:
   // count of nodes
CountBTR(T)
   if T->left == NULL and T->right == NULL then
      return 1
   endif
   return CountBTR(T->left) + 1 + CountBTR (T->right)
endCountBTR

A. There is nothing wrong, the algorithm operates as intended.
B. In the if statement condition the and should be replaced by an or.
C. On the then branch of the if statement the algorithm should return 0.
   *D. The algorithm doesn’t correctly handle nodes with exactly one child.
E. The algorithm doesn’t count all nodes in a binary tree but rather only the internal nodes.

14. Which of the following is true?

A. IDLE is a SW environment that facilitates programming in Python
B. IDLE includes an editor that knows Python and provides syntactic highlighting
C. IDLE finds all programming errors
D. A, B, and C
   *E. A and B

15. The Python code a%b:

A. Evaluates to 1 when a and b are prime relative to each other.
   *B. Evaluates to 0 when a is a multiple of b or when a is 0.
C. Evaluates to a number greater than b.
D. Swaps variables a and b.
E. A and B.
16. What does the following Python code print out:

```python
a = 'This is a string'
b = a[10:12]+a[8]+'r'
print(b)
```

A. Star  
B. start  
*C. star  
D. Tart  
E. strar

17. A game implemented in Python has to keep a ball inside the display window. The position of the center of the ball is encoded with the variable `ballPosition`, the window size is \( w \times h \), and the ball radius is \( r \). Which test would indicate that the ball is outside the window:

A. \( \text{ballPosition}.x < r \) and \( \text{ballPosition}.x > \text{width}-r \) or \( \text{ballPosition}.y < r \) and \( \text{ballPosition}.y > \text{height}-r \)  
B. \( \text{ballPosition}.x < r \) and \( \text{ballPosition}.x > \text{width}-r \) and \( \text{ballPosition}.y < r \) and \( \text{ballPosition}.y > \text{height}-r \)  
*C. \( \text{ballPosition}.x < r \) or \( \text{ballPosition}.x > \text{width}-r \) or \( \text{ballPosition}.y < r \) or \( \text{ballPosition}.y > \text{height}-r \)  
D. \( \text{ballPosition}.x < r \) or \( \text{ballPosition}.x > \text{width}-r \) and \( \text{ballPosition}.y < r \) or \( \text{ballPosition}.y > \text{height}-r \)  
E. None of the above
18. The Python graphics library allows creating colors with the function color_rgb(red, green, blue).

A. color_rgb(0, 255, 0) is green.
B. Both color_rgb(255, 0, 0) and color_rgb(100, 0, 0) are red, but the second color is darker.
C. color_rgb(127, 127, 127) is an invalid color.
*D. A and B
E. A, B, and C

19. How will an image change as the result of 2-D convolution with the following kernel \( K = \begin{bmatrix} 0, 0, 0 \\ 0, 1, 0 \\ 0, 0, 0 \end{bmatrix} \).

A. It will get darker.
*B. It will not change.
C. It will get brighter.
D. It will get blurrier.
E. It will change to an edge map.

20. You implement a Python function that computes an output image as the arithmetic average of two input images, pixel by pixel, channel by channel. You take two pictures of a pedestrian walking on a sidewalk, without moving the camera. Then you run your function by providing the two images as input. What will the output image look like?

A. The output image will be random, it will be impossible to identify anything in it.
B. The output image will be twice as bright as the input images.
C. The output image will be identical to the input images for the parts of the scene that do not move.
D. The output image will show the pedestrian semi-transparently at two locations.
*E. C and D.
21. What will the following Python function print for the call Greeting(6, ‘p’)?

```python
def Greeting(time, aorp):
    if aorp == ‘a’:
        print("Good morning")
    elif time < 5:
        print("Good afternoon")
    else:
        print("Good evening")
```

A. Good morning  
B. Good afternoon  
*C. Good evening  
D. Good afternoon Good evening  
E. Good evening Good afternoon

22. What will the following Python code print out?

```python
def AbsArray(A):
    for i in range(len(A)):
        if A[i] < 0:
            A[i] = -A[i]
A = [10, -1, -2, -3, 19]
AbsArray(A)
print(A)
```

*A. [10, 1, 2, 3, 19]  
B. [10, -1, -2, -3, 19]  
C. [1, 2, 3]  
D. [-1, -2, -3]  
E. [10, 0, 0, 0, 19]
23. Using the Python encoding of binary trees that we have studied this semester, what is the triple corresponding to the node that stores the value 19, for the following binary tree?

A. [19, -1, -1]
B. [19, 9, 10]
C. [19, 10, 24]
D. [5, 10, 24]
E. [5, 9, 10]
24. The algorithm for drawing a binary tree first assigns horizontal and vertical coordinates to the binary tree. What are the horizontal and vertical coordinates for the node storing the value 6 in the following tree? Recall that coordinates start at 0 and not at 1.

A. 4, 2
*B. 5, 2
C. 6, 2
D. 4, 1
E. 6, 1
25. What is a good example of synchronous communication?

* A. A phone call.
B. An email.
C. A postcard.
D. A and C.
E. A, B, and C.

26. In packet switching, what data does each packet need to contain?

A. The data to be transmitted.
B. The relative location of the packet within the message.
C. The destination address.
D. A message identifier.
* E. All of the above.

27. The page rank algorithm:

A. Is used to sort internet search results.
B. Gives a higher rank to pages that provide high quality information.
C. Gives a higher rank to a page to which many pages link.
D. Gives a higher rank to a page which links to many pages.
* E. A and C.
28. What is the encryption of the word LAFAYETTE using the shift cipher with $k = 3$.

* A. ODIDBHWWH
B. NCHCAGVVG
C. ODICBHWWH
D. NCHCAGVVH
E. none of the above

29. In a mono-alphabetical substitution cipher, a permutation $P$ of the letters of the alphabet is used to replace each letter $X$ in the plain text with $P(X)$.

A. Such ciphers are vulnerable to letter frequency analysis because a given letter is always replaced with the same letter, which preserves letter frequency in the encrypted text.
B. Such ciphers are not vulnerable to letter frequency analysis.
C. Such ciphers are hard to break by trying all possible alphabet permutations because there are too many permutations.
*D. A and C
E. B and C

30. If you invent an algorithm that can factor a large number, say with 1,024 digits, in 1 second, the invention would:

* A. Make current internet encryption schemes vulnerable.
B. Earn you a paper in an algorithms journal but not much more.
C. Reinforce the safety of current internet encryption schemes.
D. Break the Vigenere cipher.
E. Fend off all attacks to the shift cipher.