Candidate Name:**Omotola Akeredolu** Today's Date:10/10/2018

Instructions: Thanks for your interest in joining the BHG Engineering team! Please answer the questions below to the best of your ability and return your answers (including code) within 1 week.

There are 3 parts to this document:

I. Free Response Questions
II. Short Answer Questions
III. Coding Challenge

I. Free Response Questions

1. Do you have any restrictions on working in the U.S., such as immigration status?
I am an International Student with OPT work authorization

2. Are you able to work in our local office (near Baltimore Maryland)?
Yes

3. Have you applied to Big Huge Games in the past? If so, when?
No

4. What area(s) of code do you enjoy working on the most? The least?
I enjoy working on the requirements of a project and watching it come to live while coding. When people ask why I enjoy coding, I always tell them coding is like building blocks, Its so fun and challenging. With every piece you put in place you experience some excitement, and once it all comes together you're amazed at your creation.
I also enjoy debugging quite a bit. I enjoy the energy and frustration that builds up as you try to figure out what the problem is. Then there's that huge relief and feeling of accomplishment once you get a solution to the problem.

While optimization is necessary, I don't enjoy it as much as the other areas I mentioned above. With optimization, I already know the code works since I wrote it before, so a lot of times I'm just re-writing the code in a different(optimized) way. As a result I don't feel as much excitement as I did when I initially wrote the code.

5. What are your areas of expertise with respect to programming and software development (graphics, gameplay, AI, systems, UI…)? What areas are you the weakest in?

I have done several game projects in which I'm given a set of game requirements and implement as expected. As a result, I'm most experienced in gameplay and UI programming.
I am least experienced in systems programming

6. Tell us about a difficult problem that you had to debug. How did you identify the problem?
As my senior year project, I worked on a party game in which there were 4 payers and all players had different roles, and goals. Towards the end of the project after all main mechanics had been implemented, and models had been imported, I had to code the winning scene. The winning scene was a simple establishing shot which slowly zeroes in on the players standing on a platform labeled 1st, 2nd, 3rd. After coding the scene, it didn't run as expected. The players were not placed on the platform as expected. They were scattered around the game world.

To solve the issue, I started out running through the code step by step and putting print statements to first of all note if the correct players were being assigned to the right spot on the platform. Once that was confirmed, then I proceeded to look into the positioning of the instantiated model objects, to make sure they matched the positioning of the platforms. This was because if players were correctly assigned to the right platform, then the issue had to be the positioning. To test this, I dereferenced two of the models so they wouldn't instantiate, and I focused on only one of the models and put some print statements to check its positioning. From there I confirmed the issue was indeed a problem with local positioning in Unity. However tweaking my calculations for the relative positioning of the prefab to the platform made no difference. I even ensured the Prefab position was initialized to (0,0,0) before instantiating. But For some reason the position was always offset after instantiating. It seemed the animator controls were having effects on the position. Realizing that solving the issue was taking longer than it should. I asked the lead developer for help, however he was stumped as well. I ended up taking a different route to the issue. Instead of doing the relative positioning, I decided to do absolute positioning with world positions in unity.

7. Describe a system or piece of code that you are proud of, and why? This can be a simple function that was highly used, or a more complex system that you implemented.
At my last internship I was given a game project with a lot of requirements. Including a budgeting system, A community system,UI, A construction system, and A grid. The grid was quite complex and gave me the most satisfaction once I had it implemented. First of all I had to develop a script with calculations to allow dynamic generation of the grid with different grid sizes at the start of the game. Secondly there were a lot of intricacies I had to implement. For example, the grid was made up of several tiles, and when a tile is clicked a building structure (e.g houses, roads, libraries,etc.) will be built on it. Some building structures take up more than one tile. If a tile already has a structure, you can't place another on top of it. Roads were also an issue because some roads where curved in one direction, some were straight, some were 4-way roads. If a tile

has a corner road, then a player can't build a 4-way road on the tile next to it. As a result all tiles had to be aware of their adjacent tiles and the structures on them.
The whole grid system took me about 2 weeks to get a working program although it was still quite buggy.

8. Have you ever had to optimize code? How do you approach it? What are common ways to fix performance issues? What are common causes of slow code?

When it comes to optimizing code I tend to take a step back and look at my approach to the problem. I have noticed that I initially tend to use a lot of for loops when approaching problems. So when optimizing I start at these loops. How big is the array or object we are looping over? Is it absolutely necessary to loop over the object? I then start looking into other data structures that might provide better time complexity for searches or access depending on the reason for looping.
Also I look out for simple manipulation functions provided by a programming language (such as sort or index functions in python) that look simple on the surface but add to the complexity of the program
If space is a concern, then I tend to look at the data structures I'm using to see if they can be optimized further. Like using a linked list or arraylist which allow dynamic allocation instead of an array which uses up a larger predefined chunk of memory.

9. What are some common things that use a lot of memory in games, and how can you mitigate their memory overhead?

-Models/Textures/Open World: Aside getting lower poly models and textures from modelers, you could also only load textures for the current section of the map or scene the player is currently in. When the player moves away from that section of the map to a different section you can destroy the other models and unload the textures for the previous sections and load the ones for the current section. This helps to keep memory under control.

-Projectiles: Projectiles such as bullets tend to pool in the game really quickly and take up memory. To solve this you should place a timer on the projectiles so they self destroy after a certain amount of time. You could also let the projectiles self destroy once they collide with another object

Saving Games -: Saving games takes up a lot of memory because you'll be saving everything about the game up until the player saved the game (characters location, world state, inventory items and amounts etc). If memory is a big concern, Checkpointing can be considered. Checkpoints allow the character to respawn with default settings. Since game state is not saved, memory is freed up for other things. This approach works well with gameplay if the checkpoints are balanced and not too far apart.

10. What's the most complicated data structure you used and what was it used for?

I once had a small project where the user inputs a bunch of words, and then inputs a separate character, and the program has to return words from the input which start with the given character. I used a trie to approach the problem.

11. What are some strategies you employ to try to minimize dependencies across software modules?
Dependency injection is one of two ways to remove dependencies that are directly in your code. This can be done with OOP principles like Adapter or Proxy which will provide a level of abstraction for dependencies so that they are all in one place and changes can be made easily without affecting the rest of the code.

For Experienced Candidates (over 7 years experience)

Are you interested in mentoring other engineers? Do you have any experience doing so?

How do you improve and motivate junior engineers?

Do you approach training and motivation of senior engineers differently than with junior engineers?

II. Short Answer Problems

1. The color of a pixel can be represented using the HSV color model, where the value of each component is: Hue=0 - 500, Saturation=0 - 100, Value=0 - 100. What's the smallest number of bits needed to represent a color in this model?

Hue is too long to be represented in a byte so it will be represented in a short which takes 16bits
Both Value and Saturation can be represented in bytes which takes 8bits
So a color in HSV will be represent with a total of 32 bits

2. Consider the following loop, where n is a positive integer:

```
for (int i=0; i<n; i+=2)
{
        if ( /*test*/)
                /* DoSomething*/
}
```

In terms of n, what is the max number of times that DoSomething can be executed?

It will run n/2 times

3. Give the method below, are there inputs which would be problematic? If so, what are they, and what would happen?

```
public int func(int x, int y)
{
        if (x>y)
                return x*y;
        else
                return func(x-1, y);
}
```

If x is less than or equal to y it will result in an infinite loop

4. The method below checks if 3 non-negative numbers form a Pythagorean Triple. This situation occurs when the sum of the squares of two of the first two numbers equals the square of the third. For what reason would the code sometimes incorrectly return false, when provided with 3 numbers that are actually a Pythagorean Triple?

```
public boolean isPythagTriple(double a, double b, double c)
{
        double d = (a*a + b*b);
```

```
        double e = (c*c);
        return (d == e);
}
```

The function will have issues with floating point precision, such as is the case with 1, 1, $\sqrt{2}$

5. Given the following method, what is the value of the variable **total** (in terms of a or b), after the method executes:?

```
public int foo(int a, unsigned int b)
{
        int total = 0;
        unsigned int count = 0;
        while (count < b)
        {
                total += a;
                count++;
        }
        return total;
}
```

The value of total will be a*b

6. The code below is intended to find the index of the first negative integer in an array of N ints (arr[0]..arr[N-1]). Does it always work correctly? If not, in what cases does it fail, and how does it fail?

```
int i=0, firstNegative;
while(arr[i] >= 0)
{
        i++;
}
firstNegative = i;
```

It never checks if the end of the array has been reached. So if no negative value is found in the array, it will result in an Index out of bounds exception

7. Under what conditions will the method below terminate without error?

```
public void foo(String s)
{
        if (s.length() < 15)
        {
                print(s);
        }
```

```
        foo(s + "*");
}
```

None. It will keep looping and result in a timeout exception if the string is less, equal or greater than 15 . Even a Null string will result in an error

8. What does the following method return, given an input of 5:?

```
public int result(int n)
{
        return (n==1) ? 2 : (2 * result(n - 1));
}
```

2^5

9. Rewrite the result( ) function above, without using recursion.

```
public int result(int n)
{
        int result = 1;
        for (int i=0;i<n;i++){
           result*=2;
        }
        return result;

}
```

10. If doing a binary search on an array of 600 sorted elements, how many iterations (exact number) are needed in the worst case? How about the best case?

Worst case will have log(600) = 9.2288186905 ~= 10 iterations
Best case will only iterate once through the elements

III. Coding Challenge

The goal of this coding challenge is to show us that you can write code that not only works as described, but is readable, efficient, and intelligently designed. Feel free to use your choice of coding style and architecture, that reflects the best practices you use.

Instructions:

You will be creating a battle game using the 4 troops types defined in the table below. The game should be coded in Java, C# or C++ and is text based (a console app). After you're done, please answer the wrap-up questions on the next page. Then send us your code and the answers to the questions.

Name	Type	Damage per hit	Health	Preferred Target

Monkey	Ground	6	50	Ground
Flying Monkey	Air	same as Monkey	same as Monkey	Air
Wizard	Ground	6	60	ALL (Air and Ground)
Balloon	Air	8	55	Ground

Each troop type is specified by 5 data elements, defined by the columns in the table.
Note that since Flying Monkey is based on Monkey, if the designer changes the values for Monkey, then Flying Monkey should follow suit.

Step 1 - Create 2 Armies

For the first step, you'll need to create 2 armies, each consisting of 20 troops, defined in the sequence above. The first army starts with a Monkey troop, followed by a Flying Monkey, then Wizard, then Balloon, then repeat until 20 troops are there. The second army starts with Flying Monkey, then Wizard, then Balloon then Monkey, repeating… following the same pattern until you have 20 troops. Print out a list of each army's troops at the start. See the example output (at the end), for the exact army compositions.

Step 2 - Armies Engage in Battle

For the second step, the armies will battle each other in successive rounds. For each round of battle, pick the next troop from each player's army (wrap as needed). So you'll have 2 troops fighting each round (TroopA and TroopB).

Both troops attack each other in the round, by subtracting their damage per hit from the other's health. Note, the damage should be reduced by half, if the defender is not a preferred target of the attacker. If any troop's health drops to 0 or lower at the end of the round, it is dead and should not be used in any other rounds. Each troop should keep track of how much total damage **it has inflicted** on the enemy army, over all the rounds. Note, if an attacker kills a defender, the attacker's total damage increase is capped by the defender's health that round.

For each round of battle, print out what happened, for example:
"Round 12: Player 1 Wizard (health=10, totalDamage=45) vs Player 2 Monkey (health=5, totalDamage=37)"
"Player 2 Monkey was killed"
// Note: Even though wizard does 6 damage, his totalDamage goes up by only 5 when he attacks, since that's all it took to kill the Monkey that round

Continue to repeat battle rounds until one army has no troops left alive and is declared the loser.
Print out the remaining troops in the winning army, including each one's health and total damage inflicted on the enemy.

Step 3 - Pick the most outstanding troop, from the survivors of the winning army
For the final step, you need to pick the most outstanding troop from the winning army, based on the following rule.

The most outstanding troop is the first surviving troop in the army, whose total damage amount (accumulated over all rounds) has the longest run of consecutive 1s in its binary representation.

Example:
Troop 1 has totalDamage of 5 (which is 101 in binary)
Troop 2 has totalDamage of 6 (which is 110 in binary)
So Troop2 would be the most outstanding troop since it has two consecutive 1s in its binary representation.

Then print out which troop is the most 'outstanding troop' from the winning army.

Rules Summary

- Create 2 armies, each consisting of 20 troops (order as described above). Print out the army.
- Each round, pick the next troop in line from each army to battle
- The attacking troop uses its damage per hit amount to lower the defender's health.
- Damage is halved if the attacker hits a target which is not his preferred target
- The damage inflicted is added to the attacker's totalDamage counter
- There is only 1 attack per side per round
- If any troop health drops below 0 or lower, it is dead and is no longer used in future rounds
- Log outputs each round on what happened
- Players battle each other until no troops are left on one side
- Print out remaining troops and health of winning army
- Pick the most outstanding troop in the winning army based on the rule described above

Wrap-up Questions

1. How long did it take you to read and understand the instructions? **Initial reading took me 10 mins. As I started drawing out my approach on paper I re-read the instructions a couple of times. It took me about 20 minutes to come up with a rough structure on paper.**
2. How long did it take you to have a first cut of the program which compiled (but might be buggy or crashed)?
   Given my other commitments I spent about 3 days, I broke the code up into sections, and spent between 30 mins - 2 hours each day on some sections

3. How long did it take you to have the program completely debugged and working?
   About 4 days. I tested and debugged functions as I coded them. So I didn't have much that went wrong after the first cut

4. What was the most difficult part of the challenge?
   I initially had a superclass for all troops. However, I had a little bit of an issue with creating subclasses with superclass references. The subclass variables(health, damage etc) were always overwritten by the superclass. I decided to make the superclass an interface, so each subclass has its own variables. In the long run if the game were to be extended this approach would be suitable because each subclass can implement its functions

differently. For example an attack on the wizard can only affect it if its weak(i.e its health is below some threshold).

5. What bugs did you find and fix in your implementation?

   Initially the game was running infinitely even when health of all the troops had reached negative values. It kept re-using troops that should be dead. Turns out in my function to check if a troop is dead, I was only checking if the troop's health ==0 instead of health <=0.

6. What would you do if you had more time to improve or enhance the program?
   I didn't think much about optimizing the program.For example if the troops in an army were more than 20, maybe 10000, it could slow down the game a little because I loop over the troops a couple of times.
7. Did you enjoy the coding challenge? Any other comments/feedback?
   Yes it was fun developing the army and troops.
   Although it's a small game project, in my opinion some small changes could be made to make the game more fun. For example, the attack per round and troops could be more random so you end up with different results at the end of the game.

Example Output:

Army 1 - Initial Troops:
1. Monkey
2. Flying Monkey
3. Wizard
4. Balloon
5. Monkey
6. Flying Monkey
7. Wizard
8. Balloon
9. Monkey
10. Flying Monkey
11. Wizard
12. Balloon
13. Monkey
14. Flying Monkey
15. Wizard
16. Balloon
17. Monkey
18. Flying Monkey
19. Wizard
20. Balloon

Army 2 - Initial Troops:
1. Flying Monkey
2. Wizard
3. Balloon
4. Monkey
5. Flying Monkey
6. Wizard
7. Balloon
8. Monkey
9. Flying Monkey
10. Wizard
11. Balloon
12. Monkey

13. Flying Monkey
14. Wizard
15. Balloon
16. Monkey
17. Flying Monkey
18. Wizard
19. Balloon
20. Monkey

BATTLE
…
Round X: Player 1 Wizard (health=12, totalDamage=36) vs. Player 2 Balloon (health=19, totalDamage=48)
Round Y: Player 1 Balloon (health=37, totalDamage=48) vs. Player 2 Monkey (health=2, totalDamage=18)
Player 2 Monkey was killed
Round Z: Player 1 Monkey (health=32, totalDamage=18) vs. Player 2 Flying Monkey (health=32, totalDamage=18)
…

WINNER
Army X is the winner. Remaining troops:
1. Flying Monkey, health=X, totalDamage=X
...

The most Outstanding Troop is:
Flying Monkey, health=X, totalDamage=X

FAQ

Q: For each round, is next troop just the very next troop? Or is the next troop a random pick?
A: It's the very next troop in the army, not a random pick

Q: When coding the attack sequence, does the same troop keep attacking until it's dead or do the next set of troops attack?
A: A troop attacks once in the round, and then the next set of troops goes.

Q: Do both troops get in their attack per round or does one get the first swing?
A: Both troops get in their attack per round, (essentially at the same time).

Development Environment

If you don't have a development environment setup, there are several options, including:

Visual Studio (recommended) - You can download the free version here:
Windows: https://www.visualstudio.com/downloads
Mac: https://www.visualstudio.com/vs/visual-studio-mac/

Using Visual Studio, you can create a new Console Project, this may be in the Other or .NET section of the New Solution Wizard.

Eclipse - https://eclipse.org/downloads/