

UNIVERSITY OF LONDON

GOLDSMITHS COLLEGE

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IS52028A

Principles and Applications of Programming

Duration: 3 hours

Date and time:

This paper is in THREE parts: part A, part B and part C. You should answer ONE question from part A (either C++ or Java) and THREE questions from part B (Java) or part C (C++). Part A carries 40 marks, and each question from part B and C carries 30 marks. The marks for each part of a question are indicated at the end of the part in [.] brackets.

There are 100 marks available for this paper.

Electronic calculators must not be programmed prior to the examination. Calculators which display graphics, text or algebraic equations are not allowed.

**THIS PAPER MUST NOT BE REMOVED
FROM THE EXAMINATION ROOM**

Part A
Multiple choice Java

Question 1 Multiple choice JAVA

- (a) Which one statement is correct about the following code snippet? [2]

```
double x =5 ;
int y = x
System.out.println(x);
```

- i. it prints the 2
 - ii. it prints 2.0
 - iii. compilation error
 - iv. runtime error
- (b) What is the correct code to multiply the stored values in the array **vals** by 2? Select one option. [2]

i.

```
1 int [] vals = {2,4,6,8};
2
3 for (int i=0;i < 2 ;i++){
4     vals[i] = vals[i] * 2;
5 }
```

ii.

```
1 int [] vals = {2,4,6,8};
2
3 for (int i : vals){
4     i ++ 2;
5 }
```

iii.

```
1
2 int [] vals = {2,4,6,8};
3
4 for (int i=0; i<vals.length; i++){
5     vals[i] *= 2;
6 }
```

iv.

```
1
2 int [] vals = {2, 4, 6, 8};
3
4 for (int i =0; i < vals.size(); i++){
5     vals[i] *= 2 ;
6 }
```

(c) What is the output of the following code snippet:

```
1
2 public static void main(String args[]) {
3     try {
4         int a, b;
5         b = 0;
6         a = 2/b;
7         System.out.print("a_");
8     }
9
10    catch(ArithmeticException e) {
11        System.out.print("b_");
12    }
13
14    finally {
15        System.out.println("finally");
16    }
17 }
```

[2]

- i. a
- ii. b
- iii. a finally
- iv. b finally

(d) Which of the following is the correct code to sort elements of an ArrayList? [2]

- i. Collections.sort(listObj);
- ii. interface.sort(listObj);
- iii. listObj.sort();
- iv. Sorter.sortAsc(listObj);

(e) What is the value of x at the end of funct and why? [2]

```
void funct(){
    int x = 30;
    double y = 30.5 ;
    x ++;
    x = x + y;
}
```

- i. 42 because y is rounded up when it is added to x.
- ii. 41 because y is rounded down when it is added to x.
- iii. This code will not compile as it assigns a number value to an int.
- iv. 40 because y is rounded down when it is added to x.

(f) What is an abstract method? [2]

- i. any method in an abstract class
- ii. a method which cannot be inherited
- iii. a method which is not implemented. The implementation for this method needs to be done in a non abstract class which extends this class
- iv. a method in the child class that overrides a parent method

(g) Which of the following statements are **CORRECT**? [2]

- i. an abstract class can be instantiated
- ii. a class can implement any number of interfaces, but can only extend one abstract class
- iii. an abstract class cannot have concrete (ie non-abstract) methods
- iv. an abstract class must have the abstract key word in its class declaration

(h) If the elements A, B, C and D are placed in a queue and are deleted one at a time, in what order will they be removed? [2]

- i. ABCD
- ii. DCBA
- iii. DCAB
- iv. ABDC

(i) Consider the following operation performed on a stack of size 5.

```
1 Push (1) ;  
2 Pop () ;  
3 Push (2) ;  
4 Push (3) ;  
5 Pop () ;  
6 Push (4) ;  
7 Pop () ;  
8 Pop () ;  
9 Push (5) ;
```

After the completion of all operation, the number of elements present in stack are [2]

- i. 4
- ii. 3
- iii. 2
- iv. 1

(j) Which interface restricts duplicate elements?. [2]

- i. List
- ii. Map
- iii. Set
- iv. none of the above

- (k) In which Java **OOP** feature can one object acquire all the properties and behaviours of the parent object? [2]
- i. inheritance
 - ii. polymorphism
 - iii. encapsulation
 - iv. abstraction
- (l) Which of these can be used to fully abstract a class from its implementation? [2]
- i. objects
 - ii. interfaces
 - iii. packages
 - iv. none of the above
- (m) Which of these access specifiers can be used for an interface? [2]
- i. public
 - ii. private
 - iii. protected
 - iv. all of the above
- (n) If private members are to be called outside the class, which is a good alternative? [2]
- i. Add a private member function which calls the private member function.
 - ii. Add a public member function which calls the private member function.
 - iii. Add a protected member function which calls the private member function.
 - iv. Not possible.

(o) If same message is passed to objects of several different classes and all of those can respond in a different way, what is this feature called? [2]

- i. overriding
- ii. inheritance
- iii. overloading
- iv. polymorphism

(p) Given the following method:

```
1 private int f( int x, int y ) {  
2     if( x == 0 ) {  
3         return y;  
4     }  
5     else {  
6         return f( x - 1, y + 1 );  
7     }  
8 }
```

What is the value of of f(10,11)? [2]

- i. 0
- ii. 21
- iii. this recursion is incorrect
- iv. 22

(q) What type of relationship exists between **funct** in classes A and **funct** in class B? [2]

```
1 class A{
2     private void funct(){
3         System.out.println( "from class A" );
4     }
5 }
6
7 class B extends A{
8     public void funct( String x ){
9         System.out.println( "from class B:" + x );
10 }
11 }
```

- i. method overriding
- ii. method overloading
- iii. both method overriding and method overloading
- iv. neither method overriding nor method overloading

- (r) Given the following definition of Bird and Chicken, which of the given statements will not compile? [2]

```
1 abstract class Bird implements Livestock {}  
2 class Chicken extends Bird {}
```

- i. Bird bird = new Chicken();
- ii. Livestock livestock = new Chicken();
- iii. Bird bird = new Bird();
- iv. none of the above

(s) What is the output of this program?

[2]

```
1 class A{
2     public int i;
3     private int j;
4 }
5
6 class B extends A{
7     void display(){
8         super.j = super.i + 1;
9         System.out.println(super.i + "□" + super.j);
10    }
11 }
12
13 class inheritance{
14     public static void main(String args[]){
15         B obj = new B();
16         obj.i=1;
17         obj.j=2;
18         obj.display();
19     }
20 }
```

- i. 22
- ii. 33
- iii. run time error
- iv. compilation error

(t) What will be the result of compiling and running the following code?

[2]

```
1 class A{
2     int b=5;
3     A(){
4         this.b=78
5     }
6     int f(){
7         return b;
8     }
9 }
10
11 class B extends A{
12     int b;
13     B(int b){
14         this.b=b;
15     }
16 }
17
18 public class Test10{
19     public static void main(String[] args){
20         A a = new B();
21         System.out.println(a.f());
22     }
23 }
```

- i. compilation error
- ii. prints 0
- iii. prints 5
- iv. prints 8
- v. none of the above

Question 2 Multiple choice C++

(a) In your ofApp.h file you have this:

```
1 unsigned char pixels[100 * 100];
2 ofTexture tex;
```

In your ofApp.cpp file, you have this:

```
1 int size = sizeof(pixels) / sizeof(unsigned char);
2 for (int i=0; i<size; i+=2){
3     pixels[i] = 255;
4     pixels[i+1] = 0;
5 }
6 tex.loadData(pixels, 100, 100, GL_LUMINANCE);
```

What pattern will this generate?

Select ONE option:

[2]

- i. A checkerboard pattern
- ii. A white noise pattern
- iii. The program will crash as the loop goes beyond the bounds of the array
- iv. Vertical, alternating white and black lines.

(b) What is wrong with the following code?

```
1 int main(){
2     int pixels[];
3 }
```

Select ALL that apply:

[2]

- i. The array is being created on the stack but there is no 'new' keyword
- ii. The array size has not been specified
- iii. int is not a type - you must specify signed or unsigned
- iv. The main function does not take any arguments.

(c) You see the following code:

```
1 unsigned char pixels [1024*768];
```

which statements are true?

Select ALL that apply

[2]

- i. The array can store values in the range -127 to 127
- ii. The array takes up 786,432 bytes of memory
- iii. The array can be increased in size when the program is running
- iv. The array is two dimensional

(d) Which of the following will iterate over all items in a `std::vector`?

Select ALL that apply

[2]

i.
1 `std::vector<int> v = {5,4,3,2,1};`
2
3 `for (int i=0;i<v.length();++i){`
4 `std::cout << v[i] << std::endl;`
5 `}`

ii.
1 `std::vector<int> v = {5,4,3,2,1};`
2
3 `for (int& i : v){`
4 `std::cout << i << std::endl;`
5 `}`

1 `std::vector<int> v = {5,4,3,2,1};`
2
3 `for (int i=0;i<v.size();++i){`
4 `std::cout << v[i] << std::endl;`
5 `}`

iii.
1 `std::vector<int> v = {5,4,3,2,1};`
2
3 `for (int i : v){`
4 `std::cout << i << std::endl;`
5 `}`

(e) Which constructor will be called?

```
1 class Car {
2     public:
3         Car(){}
4         Car(int _cylinders) : cylinders(_cylinders){}
5
6     private:
7         int cylinders;
8
9 };
10
11 int main()
12 {
13     Car car{12};
14 }
```

Select ALL responses that apply

[2]

- i. Car() as the basic constructor is always called
- ii. Car(int) as we are sending in an int
- iii. Neither as you cannot use curly braces to call a constructor.
- iv. Neither as it is not possible to have two constructors.

(f) What is the value of x at the end of the main function?

```
1 void addTen(int x)
2 {
3     x = x + 10;
4 }
5
6 int main()
7 {
8     int x = 10;
9     addTen(x);
10 }
```

Select ONE option

[2]

- i. 10
- ii. 20
- iii. 0
- iv. it is not possible to tell as there are two variables called x.

(g) What is the value of x at the end of the main function?

```
1 void halve(float& y)
2 {
3     y = y * 0.5;
4 }
5
6 int main()
7 {
8     float x = 10;
9     halve(x);
10 }
```

Select ONE option

[2]

- i. 10
- ii. 5
- iii. 2.5
- iv. 0.5

(h) What is the value of car1.speed at the end of the main function?

```
1 class Car {
2     public:
3         Car() : speed(0) {};
4         void goFaster() {speed ++;}
5     private:
6         float speed;
7 };
8 void speedUpMyCar(Car& car){
9     car.goFaster();
10    car.goFaster();
11 }
12 int main(){
13     Car car1;
14     speedUpMyCar(car1);
15 }
```

Select ONE option

[2]

- i. 0
- ii. 1
- iii. 2
- iv. 3

(i) Here is an extract from the openframeworks source code.

```
1 class ofAppBaseGLWindow: public ofAppBaseWindow{
2 public:
3     virtual ~ofAppBaseGLWindow(){}
4     virtual void setup(const ofGLWindowSettings &
5         settings)=0;
6     void setup(const ofWindowSettings & settings){
7         const ofGLWindowSettings * glSettings =
8             dynamic_cast<const ofGLWindowSettings*>(&
9             settings);
10        if(glSettings){
11            setup(*glSettings);
12        }else{
13            setup(ofGLWindowSettings(settings));
14        }
15    };
```

Which of the following statements are true about this code?

Select ALL that apply

[2]

- i. The class being defined in the code is called ofAppBaseWindow
- ii. The ofGLWindowSettings data passed into the setup function is passed in by reference
- iii. One of the setup functions is a pure abstract function
- iv. The class does not add any private members to the class from which it inherits.

(j) What is the output of the following program?

```
1 #include <iostream>
2
3 class Publication {
4     public:
5     virtual void getFormat(){
6         std::cout << "Unspecified in base class" << std::endl;
7     }
8     void getWeight(){
9         std::cout << "Everything has a weight" << std::endl;
10    }
11 };
12
13 class Magazine : public Publication {
14     public:
15     virtual void getFormat(){
16         std::cout << "Magazines are A4 size" << std::endl;
17     }
18     void getWeight(){
19         std::cout << "Magazines weigh 400g" << std::endl;
20     }
21 };
22
23 int main(){
24     Publication* pub = new Magazine();
25     pub->getFormat();
26     pub->getWeight();
27 }
```

Select ONE option

[2]

- i. It will not compile as you cannot store a Magazine object in a Publication variable
- ii. Magazines are A4 size
Magazines weigh 400g
- iii. Unspecified in base class
Everything has a weight
- iv. Magazines are A4 size
Everything has a weight

(k) You see a function like this:

```
1 void addWidget(Widget* widget);
```

Why are you able to send it a regular variable like this?

```
1 Widget btn;  
2 addWidget(&btn);
```

Select ONE option

[2]

- i. The & returns the memory location of btn, and a pointer is a memory location
- ii. The & converts the stack variable btn into a heap variable
- iii. The type of btn is Widget and the function expects a parameter of type Widget
- iv. The btn variable is a pointer and the function expects a parameter of type pointer to Widget.

(l) what is wrong with this code? Select all that apply.

```
1 cout << "Hello," << name << '\n';
```

Select ALL correct options.

[2]

- i. The std:: prefix is missing from cout
- ii. << should be >>
- iii. You must put characters in double quotes
- iv. Cross platform C++ should use std::endl to end a line.

(m) Consider the following code:

```
1 #include <iostream>
2
3 class Parent {
4 public:
5     Parent() {std::cout << "Parent□constructor!" << std::endl;}
6 };
7
8 class Child : public Parent {
9 public:
10    Child() {std::cout << "Child□constructor!" << std::endl;}
11 };
12
13 int main(){
14
15    Child testChild;
16
17 }
```

Which constructor(s) will be called?

Select ONE option

[2]

- i. Parent only
- ii. Child only
- iii. Parent then Child
- iv. Child then Parent
- v. None of the above options is correct.

(n) Consider the following code:

```
1 #include <iostream>
2
3 class Parent {
4 public:
5     Parent() {std::cout << "Parent□constructor!" << std::endl;}
6 };
7
8 class Child : public Parent {
9 public:
10    Child() {std::cout << "Child□constructor!" << std::endl;}
11 };
12
13 int main(){
14     Parent* parent = new Child();
15     delete parent;
16 }
```

Which constructor(s) will be called?

Select ONE option

[2]

- i. Parent only
- ii. Child only
- iii. Parent then Child
- iv. Child then Parent
- v. None of the above options is correct.

(o) Which of the following are true?

Select ALL that apply:

[2]

- i. The new and delete keywords are used with pointers
- ii. The new keyword allows us to assign memory in the stack
- iii. Pointers to a parent class type can point to an instance of a child class
- iv. Pointers store memory locations.

(p) You see the following class declaration.

```
1 class MainComponent    : public AudioAppComponent ,
2                        public Button::Listener
```

Which of the following are true?

Select ALL that apply:

[2]

- i. MainComponent inherits from the AudioAppComponent class
- ii. MainComponent must implement any pure virtual functions found in the Button::Listener class
- iii. MainComponent can act as an AudioAppComponent
- iv. MainComponent's constructor calls the Button::Listener function

(q) Which of the following are true, considering the use of ++i instead of i++?

Select ALL that apply

[2]

- i. We do not really need to consider code efficiency as modern compilers are smart enough to optimise our code for us
- ii. i++ is an in-place increment so is faster than ++i which is a copy, increment and store
- iii. ++i is an in-place increment so is faster than i++ which is a copy, increment and store
- iv. Some parts of a program might run thousands of times a second so efficiency is important in those parts of the code.

(r) You see a class interface like this:

```
1 virtual void    function1 (int x, double y)=0
2 void          function2 ();
3 virtual void    function3 (const Thingy &thingy)=0
```

Which of the following are true?

Select ALL that apply:

[2]

- i. function1 is pure virtual
- ii. function2 does not allow runtime polymorphism
- iii. function3 is static
- iv. function3 takes a pointer argument

(s) You see the following code:

```
1 MyClass::MyClass(AudioFormatManager& formatManager ,
2                 AudioThumbnailCache* cache)
3                 : audioThumbnail(44100, formatManager, cache),
4                 sourceLoaded(false),
5                 position(0.0)
```

Which of the following statements are true?

Select ALL that apply:

[2]

- i. The AudioThumbnailCache parameter is being passed by value
- ii. The Waveform class has a data member called sourceLoaded
- iii. The AudioFormatManager parameter is being passed by reference
- iv. The type of the cache parameter is AudioThumbnailCache

(t) An enum class is defined as follows:

```
1 enum class AudioPlayerState {nofile,stopped,playing};
```

Which of the following is the correct way to use this enum?

Select ONE option

[2]

- i. AudioPlayerState->nofile
- ii. AudioPlayerState.nofile
- iii. AudioPlayerState::nofile
- iv. AudioPlayerState.nofile()

Part B

Written answer questions JAVA

Question 3 Classes & Encapsulation

(a) List two access modifier and explain the role of each one of them. [2]

(b) Can you identify the member visibility error in this code ?

```
1
2 class Base{
3     private int var = 48;
4 }
5 class Child extends Base{
6     void methodOfChild(){
7         System.out.println(var);
8     }
9 }
```

[3]

(c) Write a class called FootballTeam in a package called football. We want to be able to access the class FootballTeam from any package. [3]

(d) Add fields for the following properties, which **cannot** be accessed outside of the class: name of the team, number of wins and number of losses [3]

(e) Write a constructor that accepts the name of the team, the number of wins, and the number of losses as arguments and sets the class properties to those values. This constructor should be accessible from any package. [3]

(f) Write a second constructor that takes only the name of the team as an argument. This constructor should set the name of the team to the argument and the set the number of wins and losses to 0. (Hint: The body of this constructor should be one line and it should call the first constructor.) This constructor should be accessible from any package [3]

(g) Write a toString() methods that return the name of the team, the number of the wins, and the number of losses. [3]

Question 4 Inheritance & Polymorphism

(a) Explain the difference between an interface and an abstract class.

[4]

(b) What is the output of the following program:

```
1 class A{
2     String s = "Class_A";
3 }
4 class B extends A{
5     String s = "Class_B";
6     B(){
7         System.out.println(super.s);
8     }
9 }
10 class C extends B{
11     String s = "Class_C";
12     C(){
13         System.out.println(super.s);
14     }
15 }
16 public class MainClass{
17     public static void main(String[] args){
18         C c = new C();
19         System.out.println(c.s);
20     }
21 }
```

[2]

(c) You are asked to write a program to represent geometric shapes and some operations that can be performed on them. The idea here is that shapes in higher dimensions inherit data from lower dimensional shapes. For example sphere is a three dimensional circle and cylinder is another kind of three dimensional circle. The circle, sphere, and cylinder all share the attribute radius. Your program will consist of the following classes: **Shape**, **Circle** and **Sphere** and two interfaces **Area** and **Volume**.

- i. Give the code for both interfaces, **Area** and **Volume**. The Area interface has an abstract method called *computeArea()* which returns the area of a given 2-dimensional shape and the Volume interface contains an abstract method called *computeVolume* which returns the area of a given 3-dimensional shape. [4]
- ii. Give an implementation of the class **Shape**. This class has one instance variable to hold the name of the shape and constructor to initialise it. [2]
- iii. Give an implementation of the class **Circle** which extends shape and implements the interface **Area**, this class should an extra field called *radius* and constructor to initialise all the required fields. This constructor should call that of the superclass when required. The class **Circle** has to have an implementation of the method *computeArea*. [4]
- iv. Give an implementation of the class **Sphere** which extends the class **Circle** and implements the interface **Volume**. This class has to have a constructor which calls that of the super class, **Circle** as well as an implementation of the method. *ComputeVolume*. [4]

Question 5 Date Structure

- (a) Explain the difference between an ArrayList and LinkedList. given the advantage and the disadvantage of each. [4]

- (b) Given the following code snippet:

```
1 public static Queue<String> mystery(Queue<String> q) {
2     Stack<String> st = new Stack<String>();
3     while (!q.isEmpty()) {
4         st.push(q.remove());
5     }
6     while (!st.isEmpty()) {
7         q.add(st.pop());
8     }
9     return q;
10 }
```

What will be printed if the following code is executed?

```
1 Queue<Integer> q = new LinkedList<Integer>();
2 q.add("a");
3 q.add("b");
4 q.add("c");
5 System.out.println(mystery(q));
6 }
```

- (c) Consider the following TestA class: [6]

```
1
2 public class TestA{
3     static int x;
4     public static void main(String[] args){
5         ArrayList<String> aList = new ArrayList<String>();
6         aList.add("hello");
7         aList.add("goodbye");
8         /*1*/ while(!(aList. ___ (0))){
9             /*2*/ System.out.println(aList. ___ (0));
10            /*3*/ aList. ___ (0);
11        }
12    }
13 }
```

The main method in the TestA class should print out each String in the aList variable. Elements of aList are deleted once they have been printed.

Each numbered line in the TestA class has a missing ArrayList method name indicated by underscores (___). Identify each missing ArrayList method together with its line number. [6]

(d) Given the following code snippet:

```
1 static Map<String, Integer> doSomething(List<String> words){
2     Map<String, Integer> map = new TreeMap<>();
3     Iterator it = words.iterator();
4     while(it.hasNext()){
5         String word = (String)(it.next());
6         word=word.toLowerCase();
7         if (map.containsKey(word)){
8             map.put(word,map.get(word)+1);
9         }
10        else {
11            map.put(word,1);
12        }
13    }
14        return map;
15 }
```

What is printed when the following code snippet is executed:

```
1 ArrayList<String> words = new ArrayList<>();
2 words.add("World"); words.add("game");
3 words.add("football");
4 words.add("Football");
5 words.add("Game");
6 System.out.println(doSomething(words));
```

[4]

Question 6 Exceptions

- (a) i. Explain the java Exception hierarchy.
ii. How Can you Catch Multiple Exceptions?

[8]

- (b) Change the divide method so that it throws an IllegalArgumentException with an appropriate message if b is zero.

```
1 public static double divide(double a, double b) {  
2     return a / b;  
3 }
```

[4]

- (c) Change the printQuotient method so that it catches the IllegalArgumentException thrown by divide and prints the message the divisor is zero if it is thrown.

[8]

Question 7 iterations & methods

(a) Consider the consider the following code snippet:

```
1
2     if ((a>b)&&(b>c)&&(c>d)&&(e>5))System.out.println("
3     Mercury");
4     if ((a>b)&&(b>c)&&(c>d)&&(e<=5))System.out.println("Venus
5     ");
6     if ((a>b)&&(b>c)&&(c<=d))System.out.println("Earth");
7     if ((a>b)&&(b<=c))System.out.println("Mars");
8     if (a<=b)System.out.println("Saturn");
```

Rewrite the above code that it has the same behaviour, but instead of stand alone **if** statements, consists of nested **if/else** statements.

[4]

(b) Given the following method:

```
1 public static String[] mystery(String[] args) {
2     int i = 0;
3     while (i < (args.length + 1)/2) {
4         String hold = args[i];
5         args[i] = args[args.length - (++i)];
6         args[args.length - i] = hold;
7     }
8     return args;
9 }
```

- i. Explain what does the method **mystery** do. [3]
- ii. Given the following code snippet:

```
1 String [] newArr = new String [arr.length];
2 newArr=  mystery(arr);
3 □
```

What are value of newArr[0] and newArr[3]? [3]

(c) Given the following declaration:

```
1     int[ ] data = new int [100];
2     int i;
```

Write a small segment of Java code that will shift data[50]...data[98] up one spot to the locations data[51]...data[99]. Then insert the number 40 at location data[50] [6]

- (d) Write a recursive method, **mystery(int x)**, that has one parameter which is an int value called x. The method prints x asterisks, followed by x exclamation points. Do NOT use any loops. Do NOT use any variables other than x. [4]

Part C
Written answer questions C++

Question 8 Pointers, arrays and vectors

Consider the following code:

```
1 class ExtendMe {  
2     public:  
3         ExtendMe();  
4         ~ExtendMe();  
5         virtual void function1() = 0;  
6         virtual void function2();  
7     private:  
8         int stateVar;  
9         float aFloat;  
10 };
```

- (a) Write down the line or lines where each of the following occur.
- i. Constructor [1]
 - ii. Pure virtual function [1]
 - iii. Non-pure virtual function [1]
 - iv. Class data members [1]
 - v. Data and functions that are accessible from outside the class [1]
- (b) Write out a minimal class definition for a class called ChildOfExtend that inherits from this class. [5]
- (c) Write out a function prototype for a function that is called function3, returns nothing, takes a float argument and a vector of pointers to ChildOfExtend objects. [2]
- (d) Write some code which instantiates a vector of the type specified in the previous question and a for loop which puts ten ChildofExtend objects into the vector. [3]
- (e) Write the same code, but this time, for an array of pointers to ChildOfExtend objects. [2]
- (f) What would you need to do somewhere else in your code if you are creating objects like this? [1]
- (g) Write the code to do this. [2]

Question 9 Event listeners

- (a) What is an event listener used for in a program? [2]
- (b) Write a class definition for an event listener class called `ClickListener` which forces classes that inherit from it to implement a `clickReceived` function which returns nothing and receives a pointer to a `ClickableThing` object. [4]
- (c) Write a class definition for the `ClickableThing` class. It will need a function to add a `ClickListener`. It should receive a pointer to the add listener function. [3]
- (d) Write a minimal class definition for a class called `MainApplication` which extends `ClickListener` and has two `ClickableThing` data members. [5]
- (e) Write an implementation for the constructor of the `MainApplication` class. It should add itself to its `ClickableThing` data members as a listener. [3]
- (f) Write an implementation for the event listener function on your `MainApplication` class which should check which of the two `ClickableThing` was clicked and print out two different messages accordingly. [3]

Question 10 Subject

This question concerns the following code. Note that the c++ function `string::find_first_not_of` is described as follows:

Searches the string for the first character that does not match any of the characters specified in its arguments.

When `pos` is specified, the search only includes characters at or after position `pos`, ignoring any possible occurrences before that character.

```
1  std::vector<std::string> tokenise(std::string input, char sep
   ){
2  std::vector<std::string> vec;
3  int end;
4  int start = input.find_first_not_of(sep, 0);
5  std::string token;
6  do{
7      end = input.find_first_of(sep, start);
8      if (start == input.length() || start == end){
9          break;
10     }
11     if (end >= 0){
12         token = input.substr(start, end - start);
13     }
14     else {
15         token = input.substr(start, input.length() - start);
16     }
17     vec.push_back(token);
18     start = end + 1;
19 }while (end > 0);
20 return vec;
21 }
```

- (a) List all the variables used in this function, their types and give an example of data that could be stored in such a variable. [4]
- (b) What does tokenising generally mean in computer programs? [2]
- (c) Can you provide an example of a programming scenario where you might want to use a `tokenise` function? Be specific - what kind of things would you pass into the function and why? [2]
- (d) Can you call this function like this? If so, explain why. If not, explain why not. [2]

```
1  tokenise("test", "split");
```

- (e) Work out what this function would do with the input "This is a computer" for input and a space character for `sep`. For each iteration of the do-while loop, state

what the value of start and end would be at the end of that iteration and what would be stored in the vec variable. Note that `string::find_first_not_of` returns -1 if it does not find any non-matching characters.

[10]

Question 11 Subject

In this question you specify a set of classes that can be used as the basis for a simple Space Invaders like video game.

- (a) Positions in the game are represented using a Vec2d class. Write a definition for the Vec2d class. It should be created using an x and a y coordinate. It should have getX, getY, setX and setY functions. It should have a distance function that receives another Vec2d object and returns the distance between them. This is a class definition not an implementation at this stage. [3]
- (b) All the things that exist in the game world are descendants of a class called GameWorldEntity. GameWorldEntities have draw, update, setPosition and getPosition functions. get and setPosition work with Vec2d objects. Write a class definition for GameWorldEntity with the appropriate functions and data members, noting that inheriting classes need to be able to write their own update and draw functions. Leave draw as a pure virtual function. [4]
- (c) Write an implementation for GameWorldEntity's functions. [2]
- (d) Write a class definition for an Alien class that inherits from GameWorldEntity. It needs Vec2ds to represent its velocity and a setter function to set the velocity. [2]
- (e) Write an implementation for Alien's update function. It should update its own position using get and setPosition. It should move right across the screen until it reaches $x = 500$ pixels, then it should reverse direction and move until it reaches $x = 0$ pixels, then repeat. Each time it reverses direction it should drop down the screen slightly. [3]
- (f) Write a class definition for a Player class. It inherits from GameWorldEntity and it adds moveLeft, moveRight and shoot functions. [2]
- (g) Explain how you would go about designing the main controller class for the game. What kind of data would it store? How would it go about updating all the game items? Make it clear if there are any functions missing from the existing classes that you would need to add. E.g. how would you manage collision detection? [4]

Question 12 Reflecting on the course

Consider a C++ program you have written or worked on during the course.

- (a) Describe what the purpose of the program was. [1]
- (b) List **THREE** class data types used in the program and state what these data or variables did in the program. [3]
- (c) Name **FIVE** programming techniques used in the program, and explain why each was necessary. [10]
- (d) What was the most complicated part of the program? Did you work on this code? How did it work? [3]
- (e) State **ONE** clear way in which you could improve the functionality of the program. Which programming techniques would you use to improve the program and how would you go about doing it? [3]