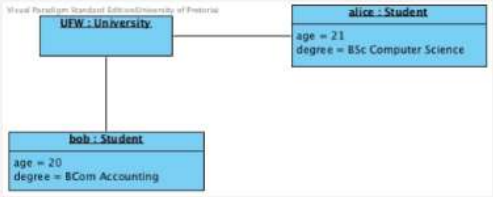
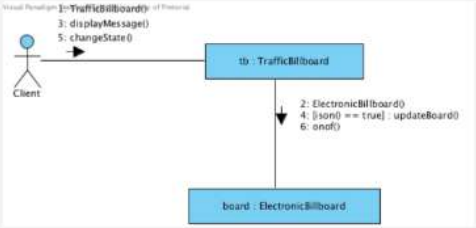
Question 1

For each of the UML diagrams in the following table, identify its corresponding type and category (Structural or Behavioural).



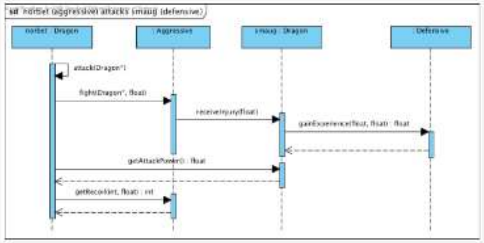
Type: **[1.a]**

Description: **[1.b]**



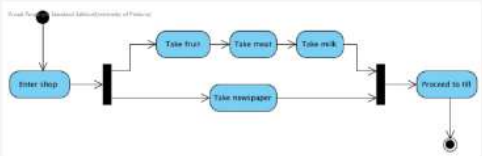
Type: **[2.a]**

Description: **[2.b]**



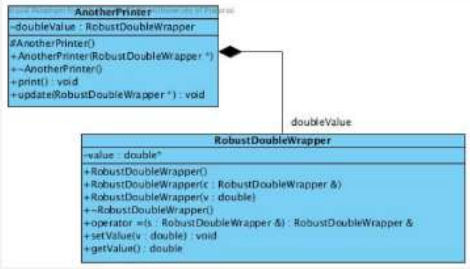
Type: **[3.a]**

Description: **[3.b]**



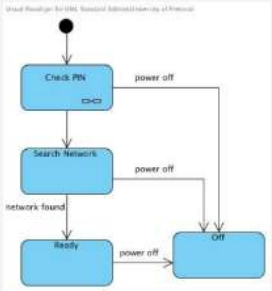
Type: **[4.a]**

Description: **[4.b]**



Type: **[5.a]**

Description: **[5.b]**



Type: **[6.a]**

Description: **[6.b]**

Correct Answers for: 1.a		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Contains	Object	
Correct Answers for: 1.b		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	Structural	
Correct Answers for: 2.a		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Contains	Communication	
Correct Answers for: 2.b		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	Behavioural	
Correct Answers for: 3.a		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Contains	Sequence	
Correct Answers for: 3.b		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	Behavioural	
Correct Answers for: 4.a		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Contains	Activity	
Correct Answers for: 4.b		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	Behavioural	
Correct Answers for: 5.a		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Contains	Class	
Correct Answers for: 5.b		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	Structural	
Correct Answers for: 6.a		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Contains	State	
Correct Answers for: 6.b		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	Behavioural	

Question 2

4 out of 6 points

Question 2

Identify the pattern that is best described by each of the given statements.

(a) Avoids coupling the sender of a request to its receiver by giving more than one potential receiver a chance to handle the request. Link the receiving objects and pass the request along the list of receivers until one handles it. **[a]**

(b) A pattern that allows you to cycle through a set of objects. **[b]**

(c) Protects the construction functionality of an object to ensure that only one such object may exist. **[c]**

(d) A centralised interface that delegates requests to other classes in the system. **[d]**

(e) Provides a surrogate or placeholder for another object to control access to it. **[e]**

(f) The application of the design pattern results in two orthogonal class hierarchies that can vary independently. **[f]**

Correct Answers for: a		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Contains	Chain of Responsibility	
Correct Answers for: b		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Contains	Iterator	
Correct Answers for: c		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Contains	Singleton	
Correct Answers for: d		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Contains	Facade	
Contains	Façade	
Correct Answers for: e		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Contains	Proxy	
Correct Answers for: f		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Contains	Bridge	

Question 3

0 out of 3 points

Question 3

A group of data structures share a common interface and each one may be implemented in a variety of ways. As opposed to having to create a different class for each type of data structure/implementation combination, the client should be allowed to decide which combination they would like to use depending on the system requirements. Your solution must allow for the implementations to be interchangeable and the addition of alternative implementation at a later stage without modifying or recompiling the data structures themselves. Furthermore, your solution must allow for as few as possible classes.

Which of the following options is the most accurate description for the scenario?

Correct Answer: G. The design pattern is Bridge, an abstract data structure superclass is a Abstraction, a concrete data structure is a RefinedAbstraction.

Question 4

4 out of 6 points

Question 4

Assume that a program which will support Boolean algebra is currently under development. The first order of business is to come up with a way to construct Boolean expressions. The following classes have thus far been proposed by the development team, each with a descriptive class name indicating its functionality:

- `Expression`, which is an abstract class.
- `BinaryOperator`, which inherits from `Expression`.
- `Negate`, which inherits from expression.
- `And` and `Or`, which both inherit from `BinaryOperator`.
- `Variable`, which inherits from `Expression` and represents a single variable. This class also encapsulates the value of the variable that it represents.
- `Constant`, which inherits from `Expression`.

(a) Suppose all classes representing binary operations have a single constructor which takes two pointers to (2) Expression objects, where the first parameter represents the left hand side of the operator and the second the right hand side. Assume further that the constructor of a class representing a unary operator takes as a parameter a pointer to an Expression object, which is its only operand. The Variable class' constructor accepts a single character which represents the name of the variable. Consider the following Boolean expression , where x and y are variables:

```
(!x&&y) || (x&& !y)
```

Identify from the following options a valid statement to construct the given expression:

A. `Expression* e = new Or(And(new Variable('y'),Negate(new Variable('x'))),And(new Variable('x'),new Negate(new Variable('y'))));`

B. `Expression* e = new Or(And(new Variable('y'),Negate(new Variable('x'))),And(new Negate(new Variable('y'),new Variable('x'))));`

C. `Expression* e = new Or(And(Negate(new Variable('x')),new Variable('y')),And(new Variable('x'),new Negate(new Variable('y'))));`

D. `Expression* e = new And(Or(Negate(new Variable('x')),new Variable('y')),Or(new Variable('x'),new Negate(new Variable('y'))));`

E. `Expression* e = new Or(And(Negate(new Variable('x')),new Variable('y')),Or(new Variable('x'),new Negate(new Variable('y'))));`

F. `Expression* e = new Or(And(new Variable('x'),new Variable('y')),Or(new Variable('x'),new Variable('y')));`

Your answer: **[a]**

(b) Which of the following statements is most true for the `And` class?

A. Contains children that are either composites or leaves.

B. Do not have children, define the primitive objects of the composition.

C. Implements an Interpret operation associated with terminal symbols in the grammar.

D. Implements an Interpret operation for nonterminal symbols in the grammar. Interpret typically calls itself recursively on the variables representing R1 through Rn.

E. Both A and B are applicable.

F. Both C and D are applicable.

G. All of the options are applicable.

Your answer: **[b]**

(c) Which of the following statements is most true for the `Variable` class?

A. Contains children that are either composites or leaves.

B. Do not have children, define the primitive objects of the composition.

C. Implements an Interpret operation associated with terminal symbols in the grammar.

D. Implements an Interpret operation for nonterminal symbols in the grammar. Interpret typically calls itself recursively on the variables representing R1 through Rn.

E. Both A and B are applicable.

F. Both C and D are applicable.

G. All of the options are applicable.

Your answer: **[c]**

Correct Answers for: a		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	C	
Correct Answers for: b		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	D	
Correct Answers for: c		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	C	

Question 5

0 out of 8 points

Question 5

Consider the following code before answering the questions that follow.

```
class G {
    public:
        G();
        int function1(int i);
        int function2(int i, int j);

    private:
        int* data;
};



class J  {
    public:
        J(char* s);
    private:
        char* a;
};

class H {
    public:
        virtual int function(G* g) = 0;
};

class A : public H {
    public:
        A(char* c);
        virtual A* something() = 0;
        virtual J* g();
        virtual void f(J* j);

    protected:
        char* c;
};

class I : public H {
    public:
        I(char* c);
        virtual int function(G* g);

    private:
        A* a;
};

class B : public A {
    public:
        B(char* c);
        virtual B* something();
        virtual int function(G* g);
};
```

```
class C : public A {
    public:
        C(char* c, A* one = 0, A* two = 0, A* three = 0);
        virtual C* something();
        virtual int function(G* g);

    private:
        A* a1;
        A* a2;
        A* a3;
};

class K {
    public:
        virtual void f(J* j);
        virtual J* g();

    private:
        J* j;
};

class D {
    public:
        virtual A* f(char* c) = 0;
};

class E : public D {
    public:
        virtual B* f(char* c);
};

class F : public D {
    public:
        virtual C* f(char* c);
};
```

Hint: Sketch out the classes and their relationships.

(a) Which of the following options lists the design patterns present in the code?

A. Prototype, Proxy, Factory Method, Memento and Interpreter.

B. Composite, Template Method, Factory Method and Decorator.

C. Composite, Strategy, Bridge, Memento, Template Method and Factory Method.

D. Proxy, Factory Method, Composite and Memento.

E. Decorator, Factory Method, Template Method, Memento and State.

F. Decorator, Factory Method, Template Method, State and Memento.

G. Prototype, Proxy, Factory Method, Memento and Strategy.

Your answer: **[a]**

(b) Identify the correct roles for the class A from the following options:

A. Prototype, Composite and Proxy.

B. Originator, Component and RealSubject.

C. Originator, AbstractExpression, Prototype.

D. ConcreteProduct and Decorator.

E. Product and RealSubject.

F. Options A and B are correct.

G. Options A and C are correct.

H. Options C and E are correct

I. Options D and E are correct.

Your answer: **[b]**

(c) Identify the most accurate description for the class B from the following options:

A. Takes a snapshot of as much of the state as required by the originator.

B. Do not have children, define the primitive objects of the composition.

C. Implements an operation for cloning itself.

D. Implements an Interpret operation associated with the terminal symbols in the grammar. the interface for the product.

E. Implements the interface for the product.

F. Knows how to perform the operations associated with carrying out a request.

G. Options A, B and C are correct.

H. Options B, C and D are correct.

I. Options C, D and E are correct.

J. Options D, E and F are correct.

Your answer: **[c]**

(d) Identify the most accurate description for the class J from the following options:

A. Takes a snapshot of as much of the state as required by the originator.

B. Do not have children, define the primitive objects of the composition.

C. Implements an operation for cloning itself.

D. Implements an Interpret operation associated with the terminal symbols in the grammar. the interface for the product.

E. Implements the interface for the product.

F. Knows how to perform the operations associated with carrying out a request.

G. Options A, B and C are correct.

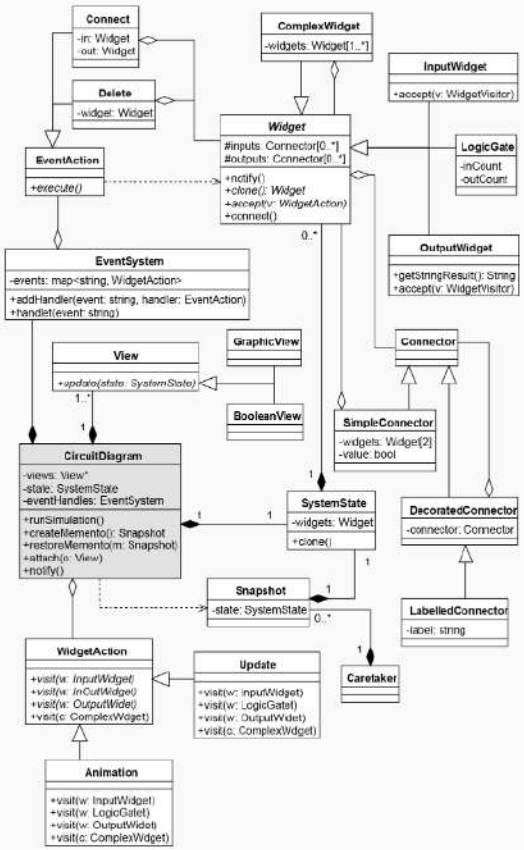
H. Options B, C and D are correct.

I. Options C, D and E are correct.

J. Options D, E and F are correct.

Your answer: **[d]**

Correct Answers for: a		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	A	
Correct Answers for: b		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	H	
Correct Answers for: c		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	I	
Correct Answers for: d		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	A	


Connect
-in: Widget
-out: Widget
Delete
-widget: Widget
EventAction
+execute()
ComplexWidget
-widgets: Widget[1..*]
InputWidget
+accept(v: WidgetVisitor)
Widget
#inputs: Connector[0..*]
#outputs: Connector[0..*]
+notify()
+clone(): Widget
+accept(v: WidgetAction)
+connect()
LogicGate
-inCount
-outCount
0..*
OutputWidget
+getStringResult(): String
+accept(v: WidgetVisitor)
EventSystem
-events: map<string, WidgetAction>
+addHandler(event: string, handler: EventAction)
+handle(event: string)
View
+update(state: SystemState)
1..*
1
GraphicView
BooleanView
Connector
SimpleConnector
-widgets: Widget[2]
-value: bool
CircuitDiagram
-views: View*
-state: SystemState
-eventHandles: EventSystem
+runSimulation()
+createMemento(): Snapshot
+restoreMemento(m: Snapshot)
+attach(o: View)
+notify()
1
SystemState
-widgets: Widget
+clone()
DecoratedConnector
-connector: Connector
Snapshot
-state: SystemState
0..*
LabelledConnector
-label: string
WidgetAction
+visit(w: InputWidget)
+visit(w: InOutWidget)
+visit(w: OutputWidget)
+visit(c: ComplexWidget)
Update
+visit(w: InputWidget)
+visit(w: LogicGate)
+visit(w: OutputWidget)
+visit(c: ComplexWidget)
Caretaker
Animation
+visit(w: InputWidget)
+visit(w: LogicGate)
+visit(w: OutputWidget)
+visit(c: ComplexWidget)

(a) Which pattern does `WidgetAction` and its subclasses form part of?

A. Prototype

B. Factory Method

C. Visitor

D. Command

E. Adapter

F. Mediator

G. Iterator

H. Composite

I. Interpreter

Your answer: **[a]**

(b) What other class(es) are also part of the design pattern referenced in (a)?

A. All Widgets and SystemState

B. CircuitDiagram and SystemState

C. All Widgets

D. SystemState

E. All Widgets and Connectors

F. Event Actions

G. Views

Your answer: **[b]**

(c) The Composite design pattern is present in this system. What classes make up this pattern?

A. All the Widget classes

B. All the connector classes

C. CircuitDiagram and WidgetAction

D. Widget, Connector and SimpleConnector

E. Widget and the EventActions

Your answer: **[c]**

(c) The Composite design pattern is present in this system. What classes make up this pattern?

A. All the Widget classes

B. All the connector classes

C. CircuitDiagram and WidgetAction

D. Widget, Connector and SimpleConnector

E. Widget and the EventActions

Your answer: **[c]**

(d) Which pattern are the Snapshot and Caretaker classes part of?

A. Prototype

B. Factory Method

C. Visitor

D. Command

E. Adapter

F. Memento

G. Decorator

H. Composite

I. Interpreter

Your answer: **[d]**

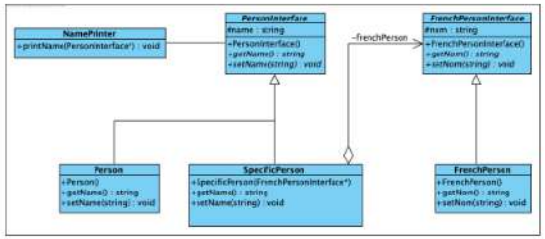
Correct Answers for: a		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	C	
Correct Answers for: b		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	C	
Correct Answers for: c		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	A	
Correct Answers for: d		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	F	

Question 7

2 out of 3 points

Question 7

Consider the UML class diagram showing an Object Adapter and answer the questions which follow.



(a) Identify the participants by writing the name of the class which represents the participant in the table below.

Participant	Class representing the participant
Adaptee	**[a.i]**
Adapter	**[a.ii]**
Target	**[a.iii]**

Correct Answers for: a.i		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	FrenchPersonInterface	
Correct Answers for: a.ii		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	SpecificPerson	
Correct Answers for: a.iii		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	PersonInterface	

Question 8

3 out of 3 points

Question 7 - continued

(b) Provide the implementation for the `printName` function of class `NamePrinter`. The function calls the relevant getter and writes the result to standard output.

Correct Answer:

```
void NamePrinter::printName(PersonInterface* person){
    cout << person->getName() << endl;
}
```

Question 9

5 out of 8 points

Question 7 - continued

(c) Given the main program below which makes use of the classes defined by the Adapter. Draw a UML Sequence diagram which could be used to reverse engineer the main program.

```
int main(){

    NamePrinter* printerService = new NamePrinter();
    PersonInterface* person = new Person();
    FrenchPersonInterface* frenchPerson = new FrenchPerson();

    person->setName("John");
    frenchPerson->setNom("Jaquelin");

    printerService->printName(person);
    printerService->printName(new SpecificPerson(frenchPerson));


    return 0;
}
```

I have completed the question on the paper provided.

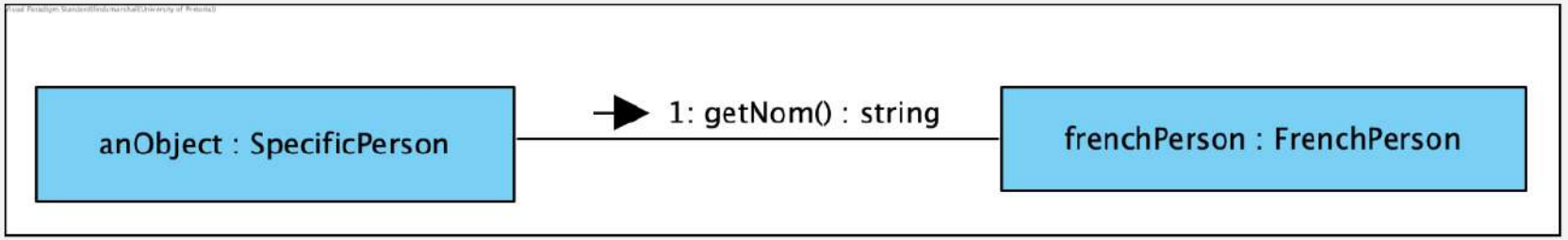
Correct Answer:

Evaluation Method	Correct Answer	Case Sensitivity
Contains	No answer needed	

Question 10 0.5 out of 3 points

Question 7 - continued

(d) Assume an object of class `SpecificPerson` exists and that its `getName` function is called. If the communication diagram for the implementation of the `getName` function is as given below, write the implementation for the function in C++.



Correct Answer:

```
string SpecificPerson::getName(){
    return frenchPerson->getNom();
}
```

Question 11 4 out of 6 points

Question 8

You have been tasked to develop a prototype of a meal builder for a company who is planning to open a fast food pop-up. As the venture is small, it was decided to create a set-menu for each meal. Currently the pop-up sells a barbarian meal and an Italian meal. Each meal includes a drink, main component, salad, starch and a dessert.

A main program used for testing is given by:

```
#include <iostream>

#include "meal.h"
#include "cashier.h"
#include "barbarianMealBuilder.h"

int main() {
    Cashier cashier;
    MealBuilder* builder;
    Meal* meal;

    builder = new BarbarianMealBuilder();
    cashier.buildMeal(builder);

    meal = builder->getMeal();
    meal->printMeal();

        // Delete all necessary objects that were created
    return 0;
}
```

Example output for this main is:

```
======================
Meal: Barbarian
======================
Drink: Castle Draught
Main: TBone
Salad: Chicken
Starch: Roast Potato
Dessert: Chocolate Cake
Price: R129
======================
```

Answer the questions that follow:

(a) For each of the following participants of the Builder pattern, identify the class that best fulfils the role.

i. Director participant **[a.i]**

ii. Builder participant **[a.ii]**

iii. ConcreteBuilder participant **[a.iii]**

iv. Product participant **[a.iv]**

(b) Identify the methods in the given main program that correspond to the following function defined by the pattern:

i. construct function **[b.i]**

ii. getResult function **[b.ii]**

Correct Answers for: a.i		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	Cashier	
Correct Answers for: a.ii		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	MealBuilder	
Correct Answers for: a.iii		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	BarbarianMealBuilder	
Correct Answers for: a.iv		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Exact Match	Meal	
Correct Answers for: b.i		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Contains	buildMeal	
Correct Answers for: b.ii		
Evaluation Method	**Correct Answer**	**Case Sensitivity**
Contains	getMeal	

Question 12

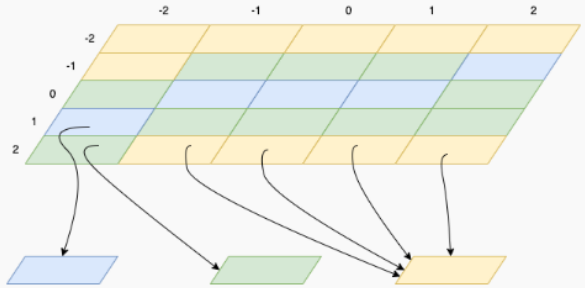
0 out of 1 points

Question 9

In a 3D environment, the modelling of the terrain can be tricky. If you assume the terrain is modelled as a grid, then laying a terrain tile, for example a hill, grass or water, per grid position is a feasible solution. Laying tiles representing the same terrain alongside each other will extend the specific terrain beyond a single tile. This makes is possible to design a terrain with rivers, mountains and large grassy plains.

Rather than creating an object per tile, tiles with the same terrain can make use of a single object for rep- resentation. Terrain variations for a specific type of terrain tile can be stored externally to the terrain tile object.

One of the terrain designers drew the following diagram to try and explain the concept of building the terrain with tiles. Tiles in the orangey colour represent hills, green the grass and blue the water. Only a few tiles are linked from the grid to their respective instances in the diagram. All tiles in the grid are linked in a similar manner.



Taking this scenario into account, answer the questions that follow.

(a) Which pattern would be the best to use to model this scenario? [a]

Correct Answer:

Evaluation Method	Correct Answer	Case Sensitivity
Contains	Flyweight	

Question 13

3 out of 5 points

Question 9 - continued

(b) Given the following tile class names `GrassTile`, `HillTile`, `TerrainTile` and `WaterTile`. Draw the tile hierarchy as a UML Class diagram to show the relationships between the tile classes.

I have completed the question on the paper provided.

Correct Answer: No

Question 14

0 out of 1 points

Question 9 - continued

(c) The terrain is implemented as a grid with origin at (0,0) – the blue tile in the middle of the example grid. The grid can expand in any direction. Expanding upwards and to the left will result in tile numbers decrementing by 1, while expanding to the right and downward will increase the tile number by 1 on the grid. For example, the top left corner of this terrain is at (-2,-2); the blue tile to the right of the origin will be in grid position (1,0); and the green tile above this tile will be at (1,-1).

You decide to define the grid using a hashtable (the map container in C++). The key of the hashtable is represented by a pair where the first element of the pair is the co-ordinate of the tile on the x-axis and the second element of the pair is the co-ordinate of the the tile on the y-axis. The value component of the hashtable is a pointer to a terrain tile at that position.

i. In which participant of the identified pattern will the terrain hashtable be defined?

Correct Answer:

Evaluation Method	Correct Answer	Case Sensitivity
Contains	FlyweightFactory	

Question 15

2 out of 4 points

Question 9 continued

ii. Provide a definiton for the hashtable called `terrainMap`.

Correct Answer:

```
map<pair<int,int>,TerrainTile*> terrainMap;
```

Question 16

0 out of 1 points

Question 9 - continued

(d) Which pattern is best suited to encapsulate additional data for each of the terrain tiles?

Correct Answer:

Evaluation Method	Correct Answer	Case Sensitivity
Contains	State	

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OK