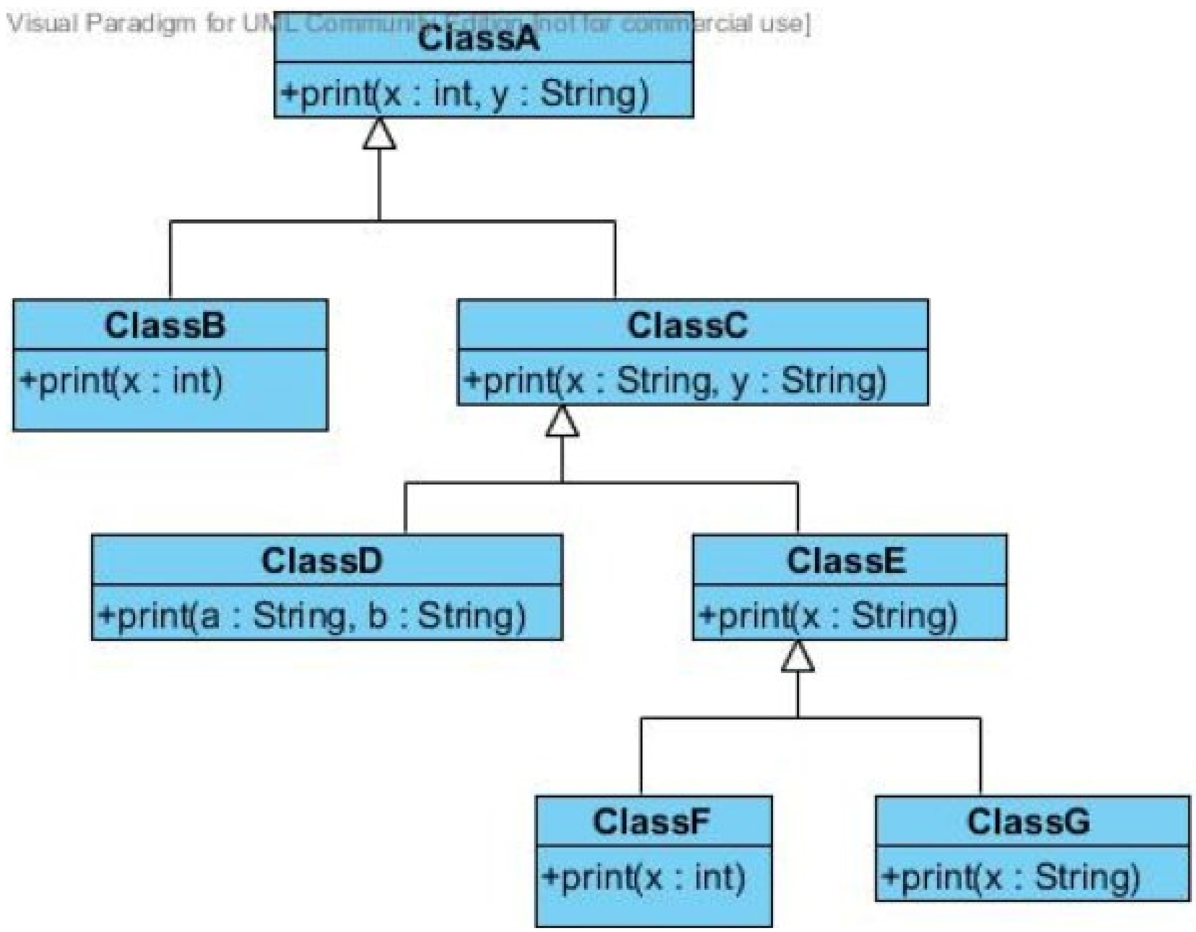
TUTORIAL 5

Inheritance & Polymorphism

Q1. Inheritance

Q1 Given the following class hierarchy diagram in the figure



superclass ← subclass

Q1 Given the following class hierarchy diagram in the figure

- Assume that ClassF z = new ClassF();
- Which class' print() method will be used for each of the message below :

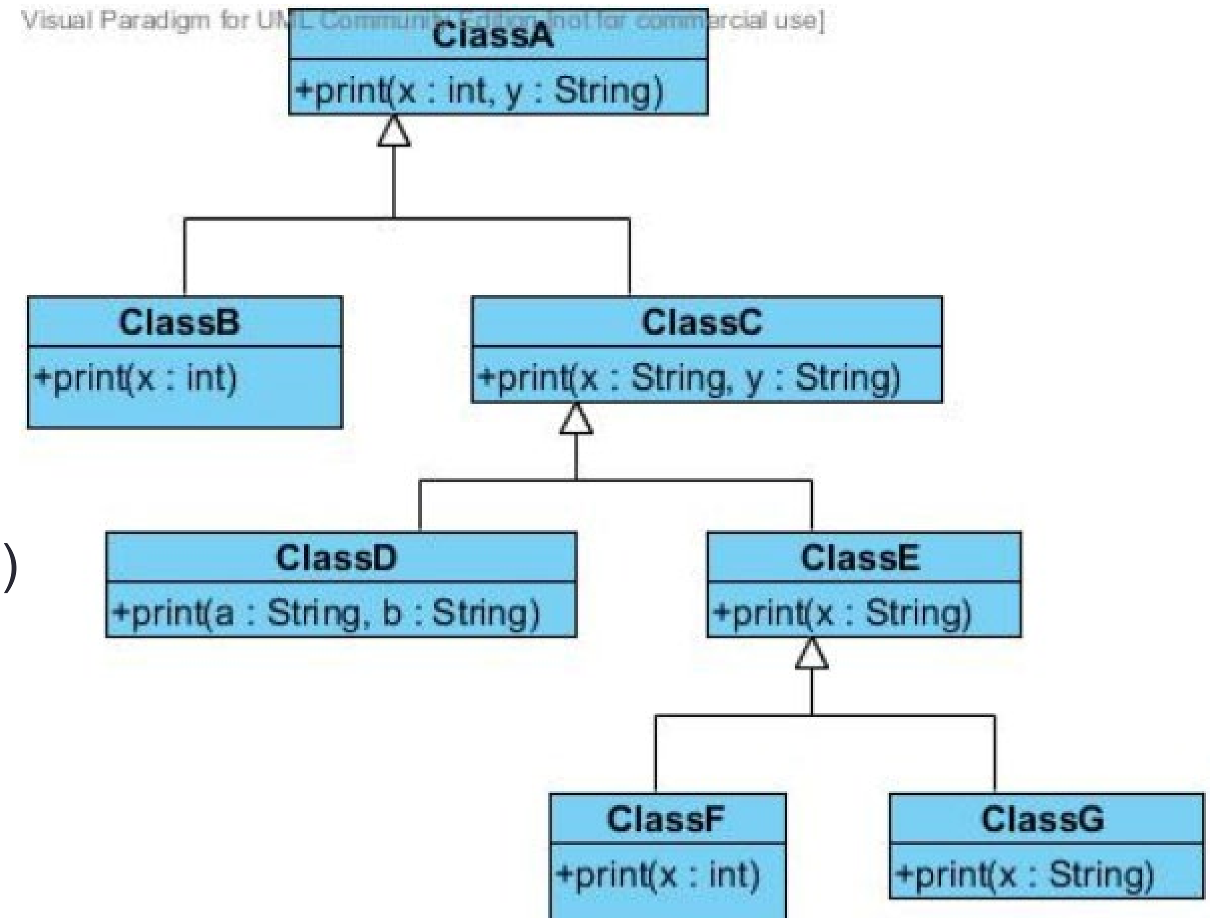
  (a) z.print(9)
    - **Class F**

  (b) z.print(2,"Cx2002")
    - **Class A**

  (c) z.print("Object")
    - **Class E**

  (d) z.print("OODP", "Java")
    - **Class C**

  (e) z.print("OODP", 2002)
    - **Compile Error!**



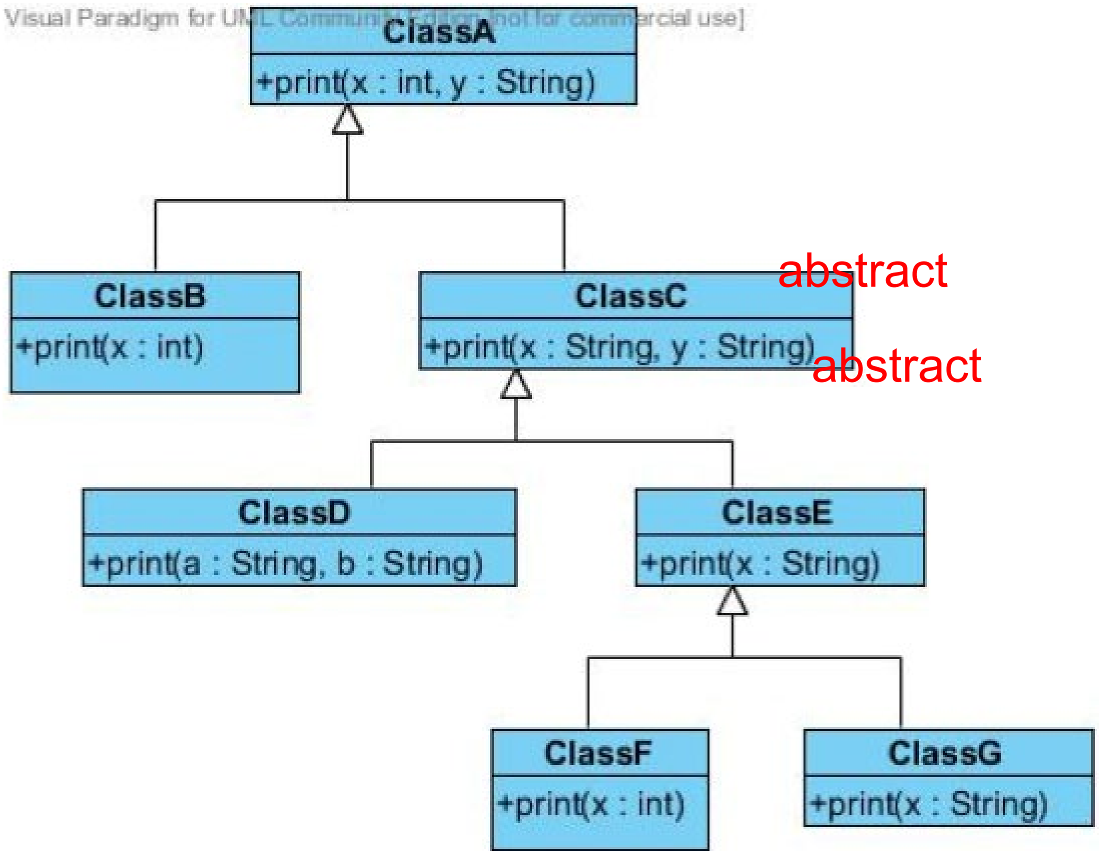
Q2. Inheritance& Polymorphism

abstract, upcasting, downcasting

Q2

Using Figure 1, and assuming all print methods just print out the contents of the its parameter values, answer the following

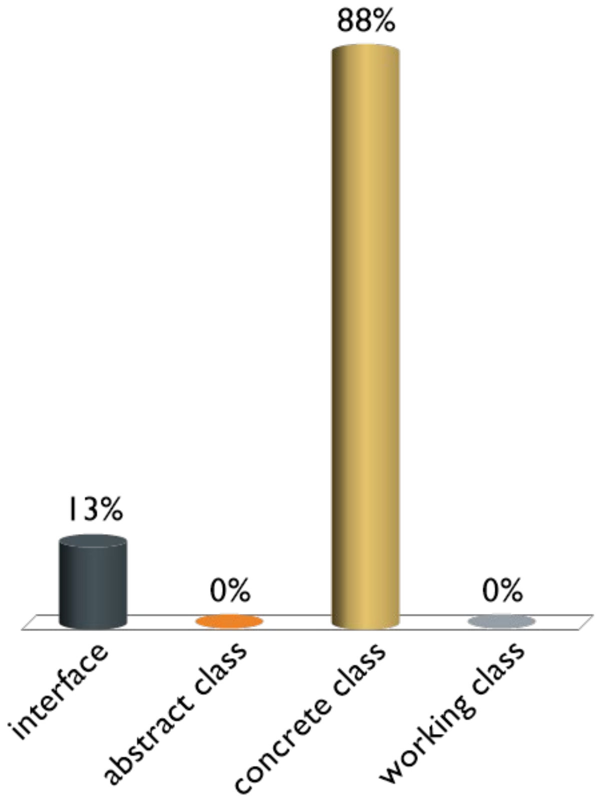
Q2(a) if the method print(String, String) in class ClassC is declared as abstract, describe what will happen and how to resolve it.



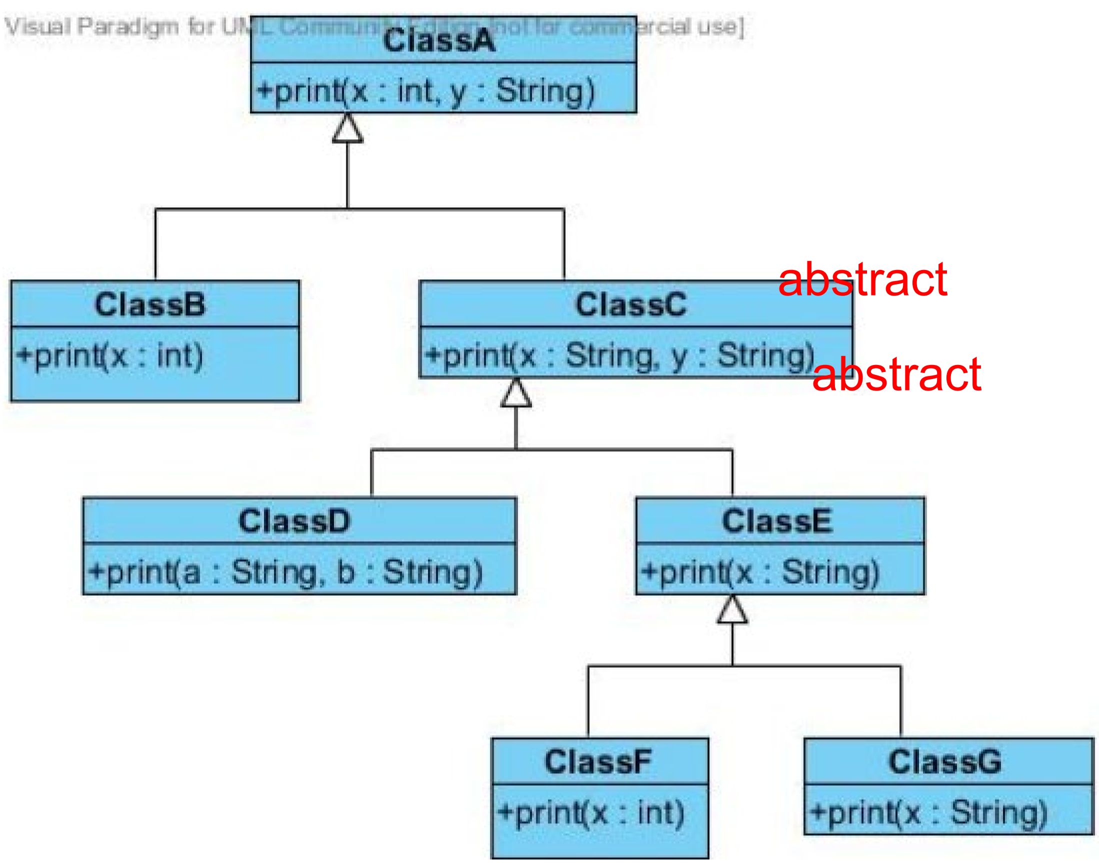
Abstract method and class

When all methods are implemented in a class, this class is known as

1. interface
2. abstract class
3. concrete class
4. working class

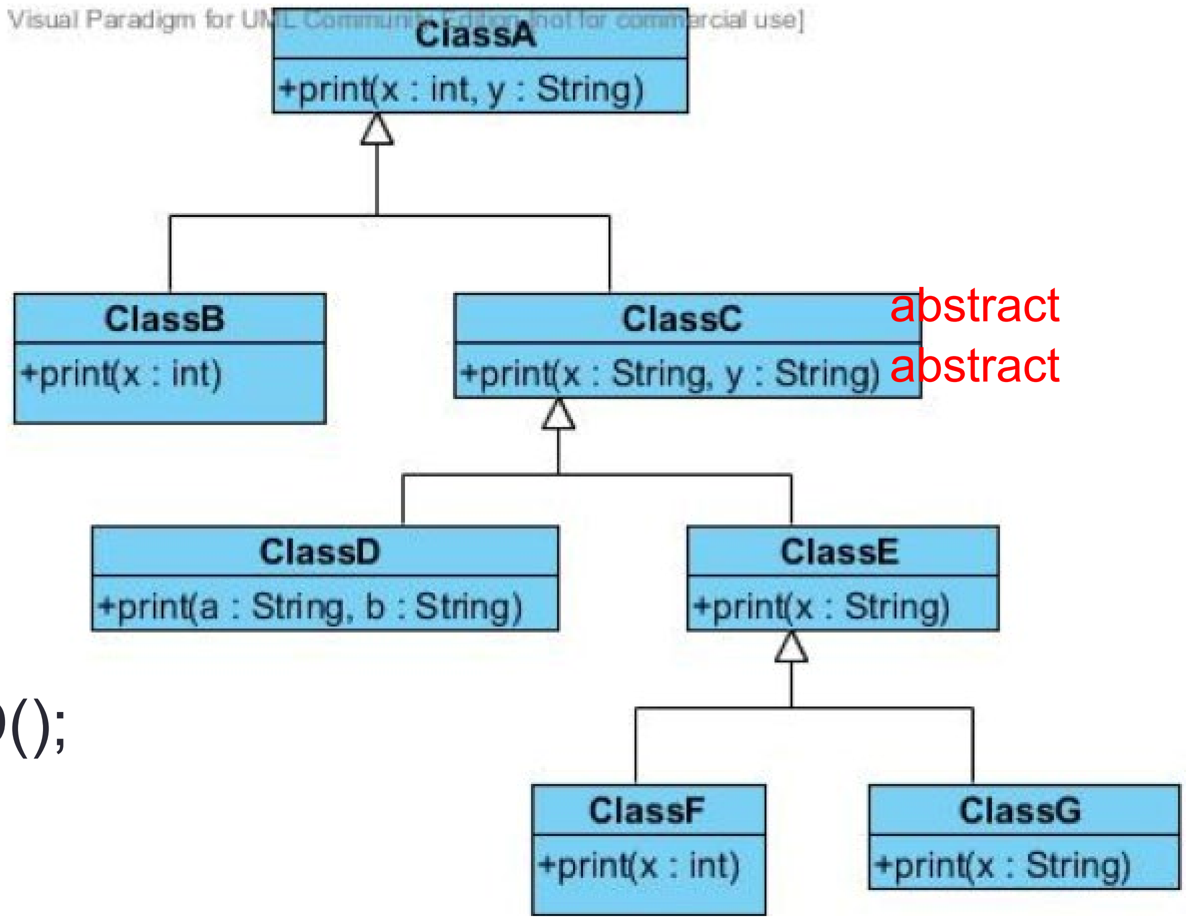


Q2(a) if the method print(String, String) in class ClassC is declared as abstract, describe what will happen and how to resolve it.



- If ClassE implements the abstract method print(String,String), then all solved.
- Else ClassE needs to be declared as abstract (pass it on…) and F and G need to implement the abstract method

- (b) After resolving (a), what will be the outcome of the following codes :



- ClassC c = new ClassD();

  c.print("hello","there");

Polymorphism
type casting

declared type   object type

Class_NameA Object_Variable_Name = new *Class_NameB*()

Class_NameA: ***Class_NameB***

<reference type>   object type

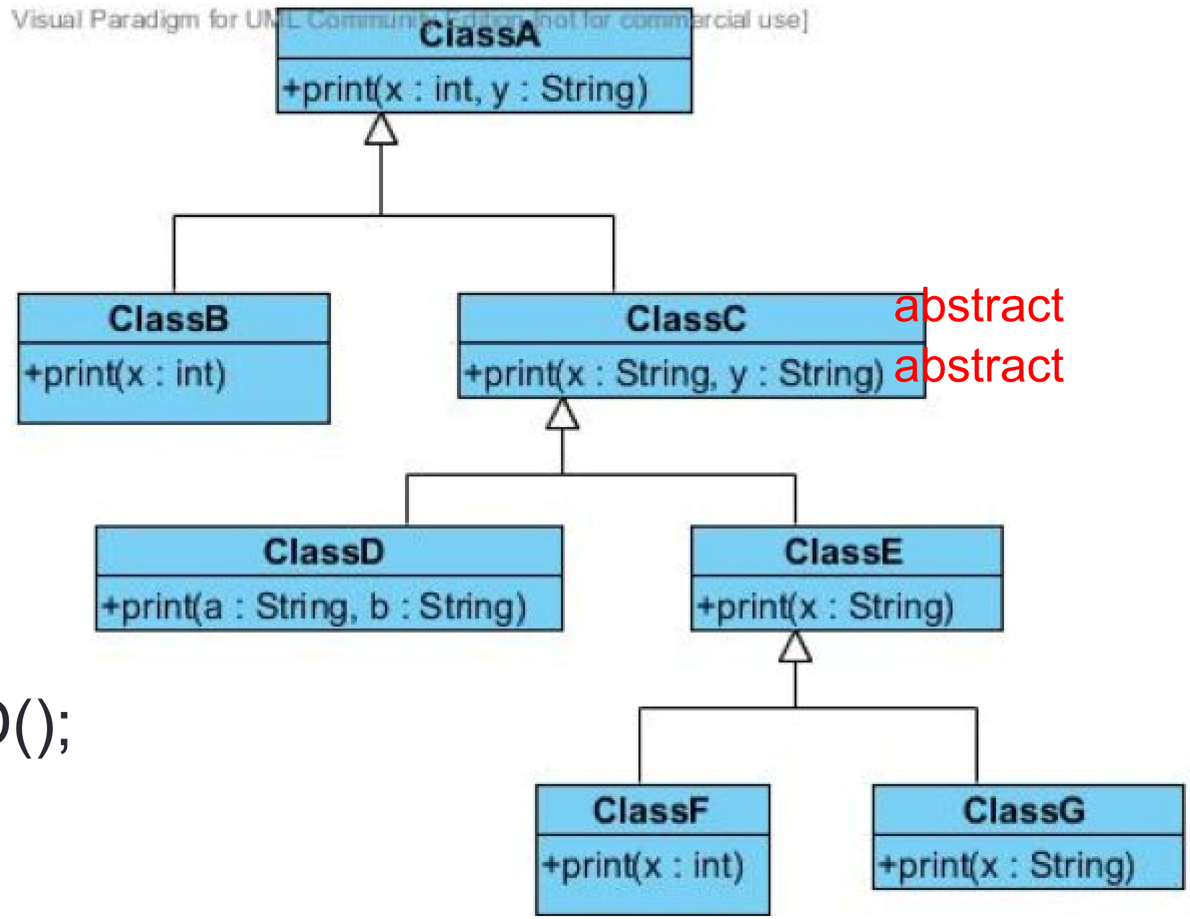
<declared type>

<variable type>

Example:

```
Animal a1 = new Cat();
```

- (b) After resolving (a), what will be the outcome of the following codes :



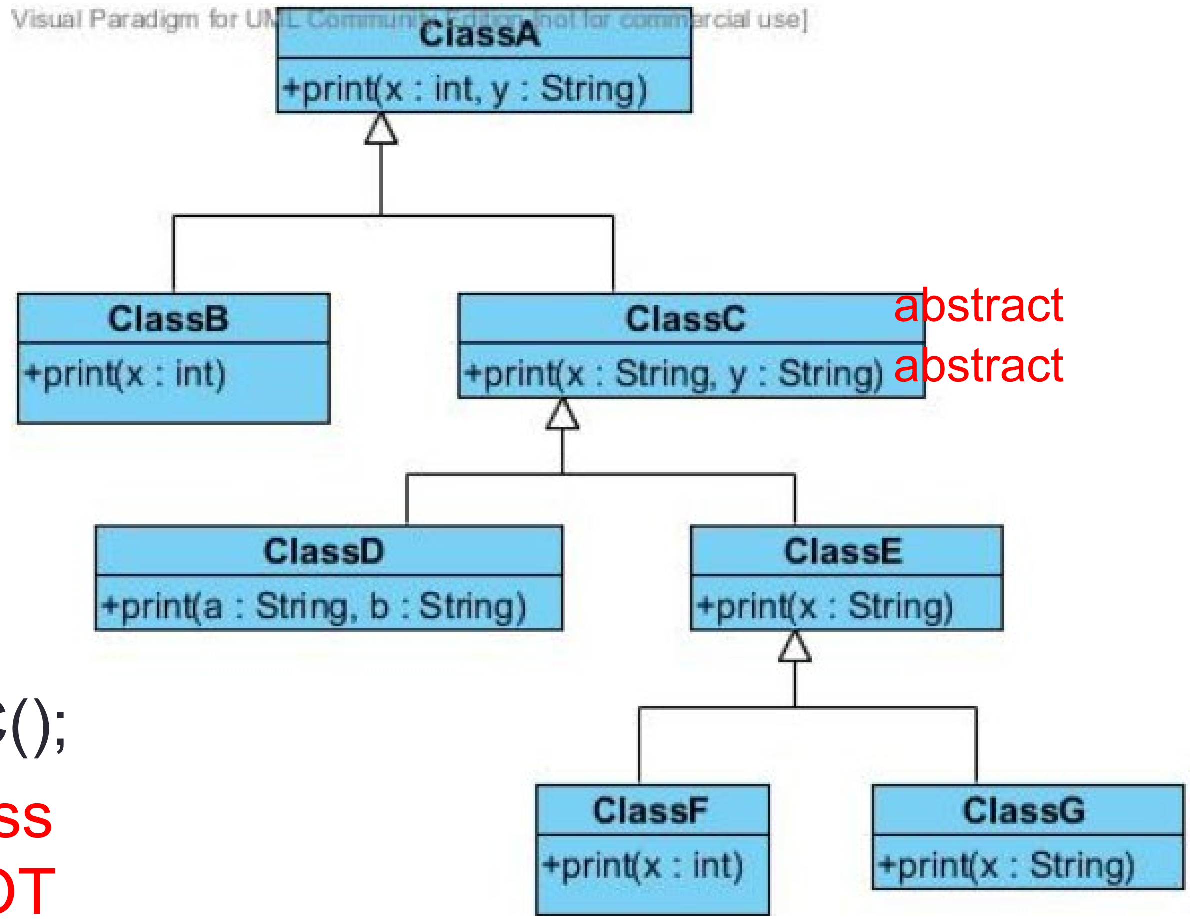
- ClassC c = new ClassD();

//upcast OK,

c.print("hello","there");

// using ClassD method

- (b) After resolving (a), what will be the outcome of the following codes :



- ClassA a = new ClassC();

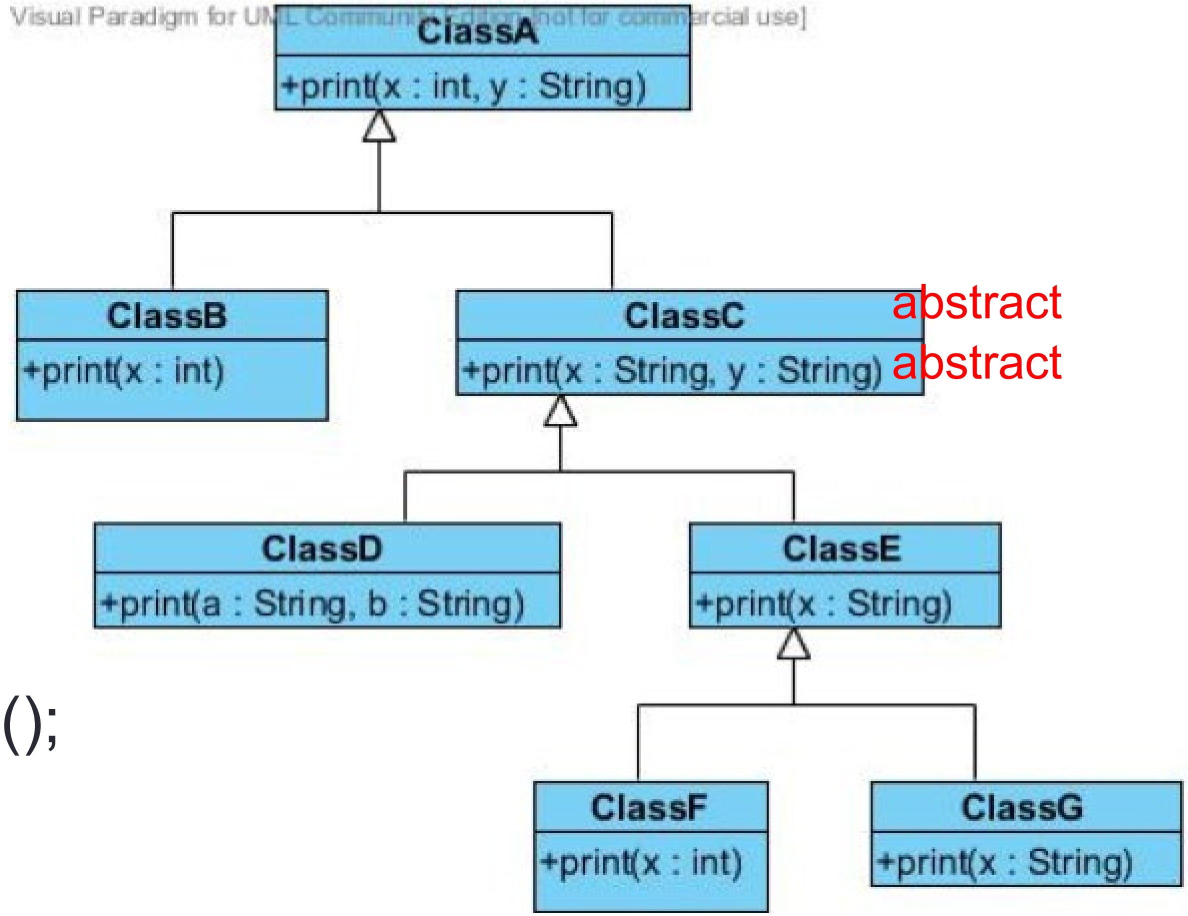
// ClassC is abstract class

// abstract class CANNOT

// instantiate obj

a.print(1,”there”);

- (b) After resolving (a), what will be the outcome of the following codes :



- ClassA a = new ClassF();

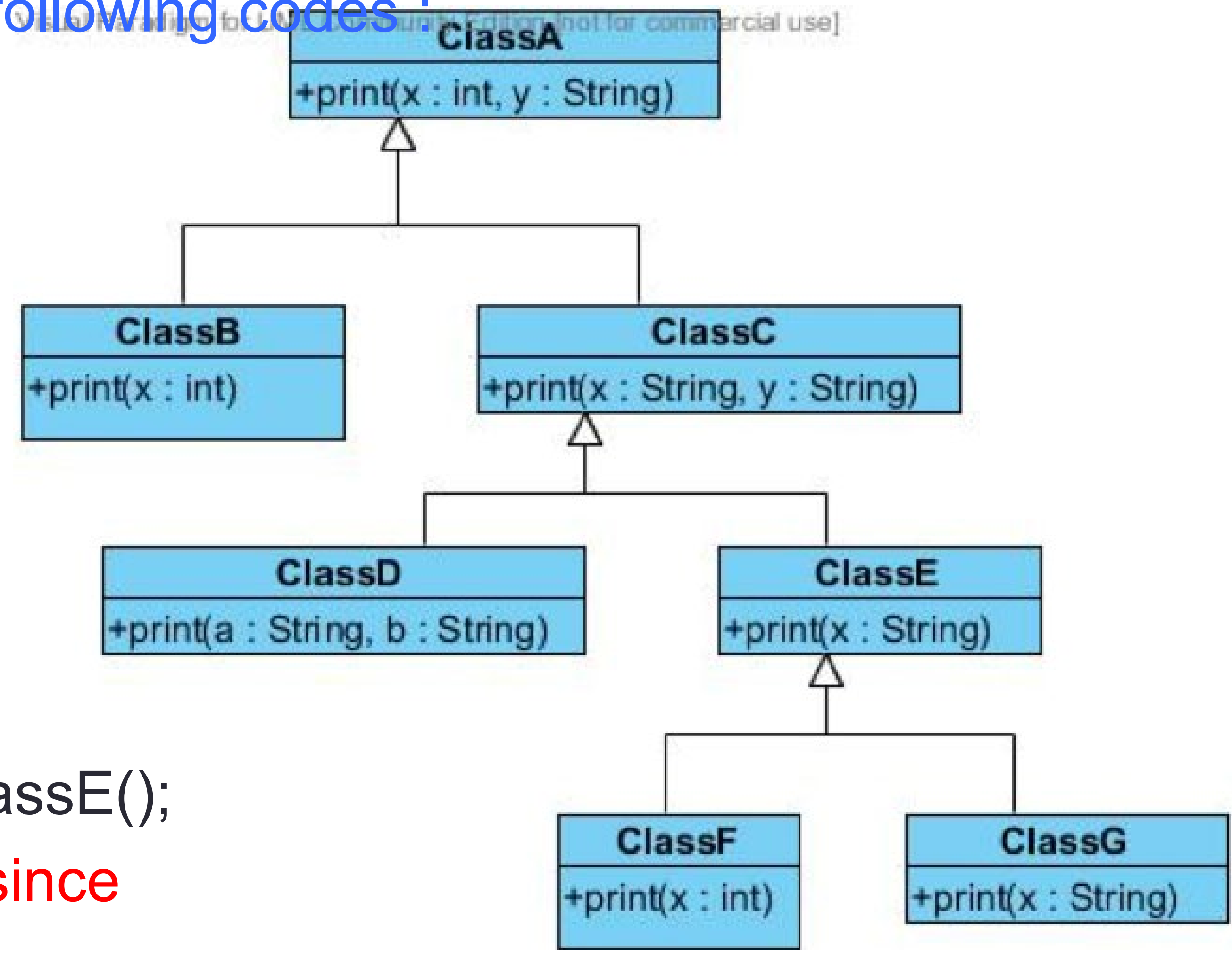
//upcast OK,

a.print("hello","there");

// compile error since ClassA

// has no print(string,string) method

- (c) Assume all classes are concrete classes, what will be the outcome of the following codes :



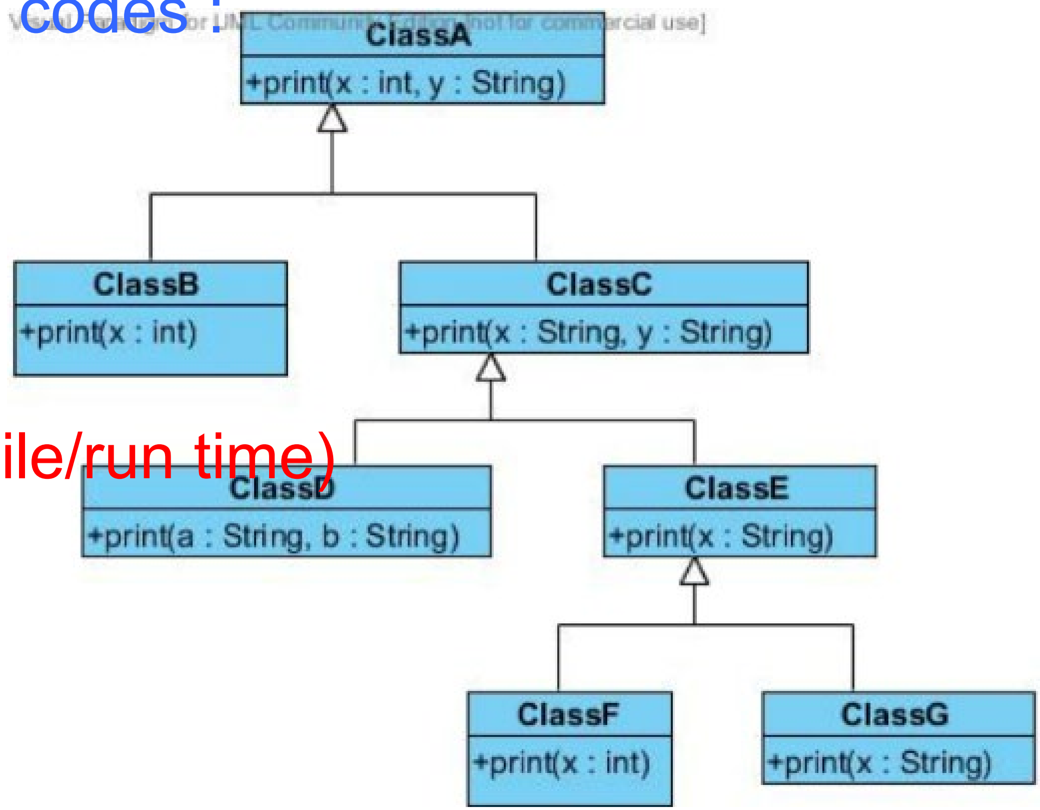
- ClassB b = new ClassE();

// Error : not upcast since

// different family line

b.print("hello");

- (c) Assume all classes are <u>concrete</u> classes, what will be the outcome of the following codes :



- ClassA a = new ClassF();

  // upcast ok (compile ok)

  a.print(12, “there”);

  // use ClassA method (compile/run time)

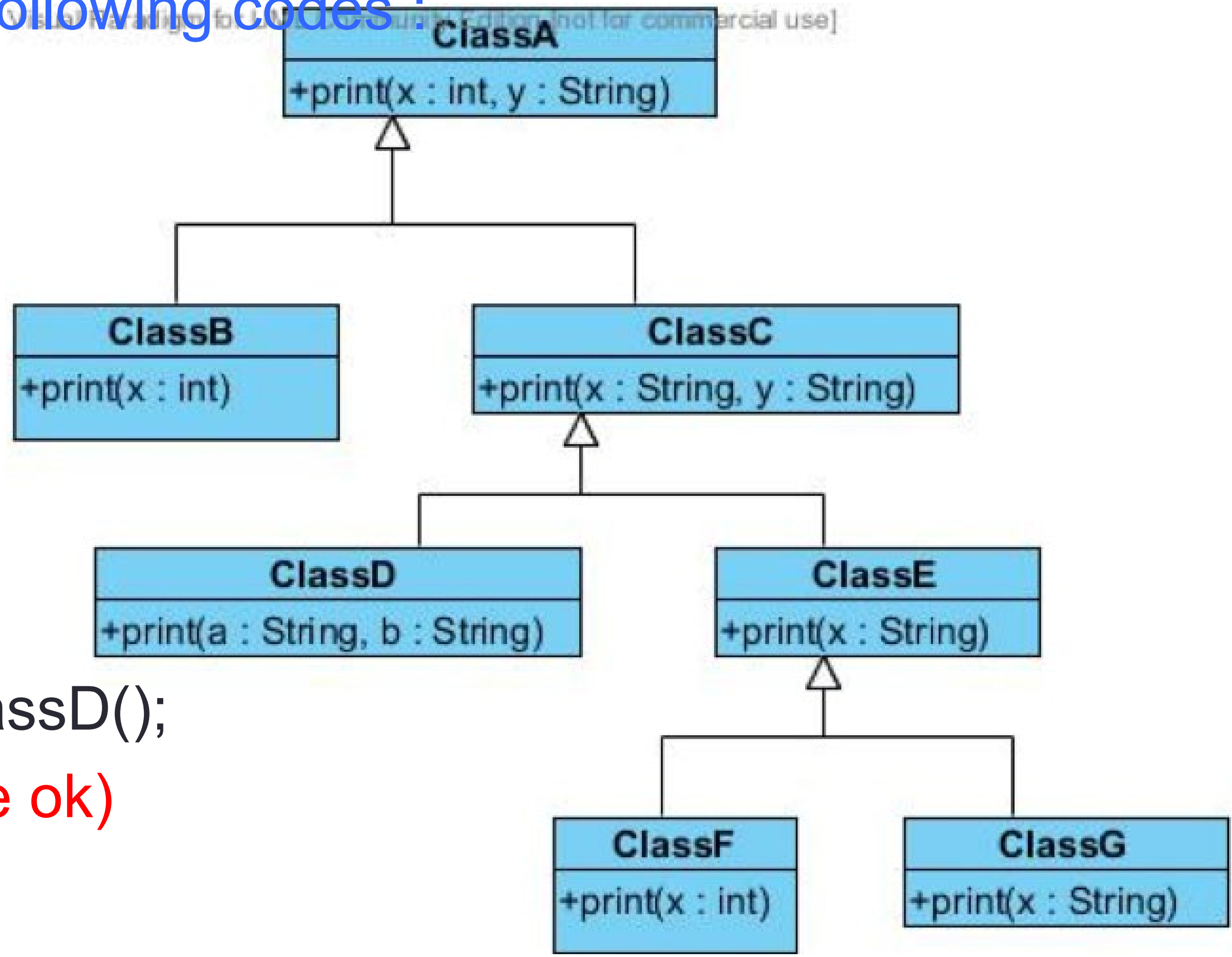
- ClassA a = new ClassF();

  // upcast ok (compile ok)

  a.print(88);

  //compile error, ClassA doesn’t have print(int) method

- (c) Assume all classes are <u>concrete</u> classes, what will be the outcome of the following codes :



- ClassC c = new ClassD();

// upcast ok (compile ok)

ClassE e = c;

// compile Error:

// explicitly downcast

// <u>ClassE e=(ClassE)c;</u>

Polymorphism
Downcasting


1G
2G
3G
4G
5G
Smart grids
Connected house
Domotics
eHealth
Entertainment
Traffic priority
Smart Car
Apps beyond imagination
Car-to-car communication

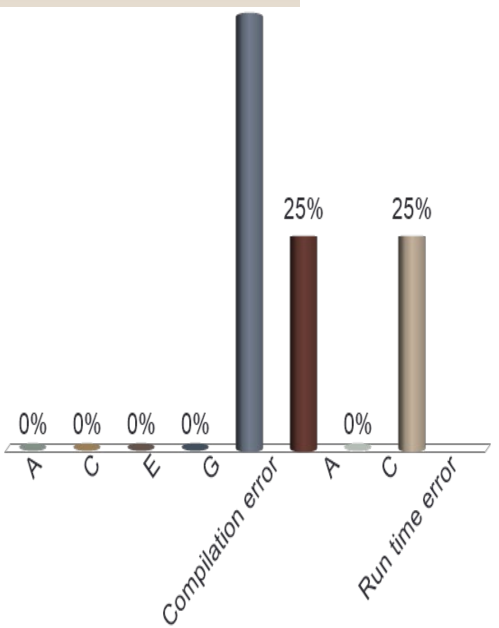
What is the output of the following program?

```
class A{
A(){
System.
}
}
class C
C(){
System.
}
}
class E extends C{
E(){
System.out.println("E");
}
}
class G extends E{
G(){
System.out.println("G");
}
}
```

```
public class Test {
public static void main(String[] args) {
```

```
A
C
Exception in thread "main"
java.lang.ClassCastException: downcasting.C
cannot be cast to downcasting.G
at downcasting.Test.main(Test.java:6)
```

A. A
B. C
C. E
D. G
E. Compilation error
F. A
C
Run time error



- ClassA a = new ClassC();

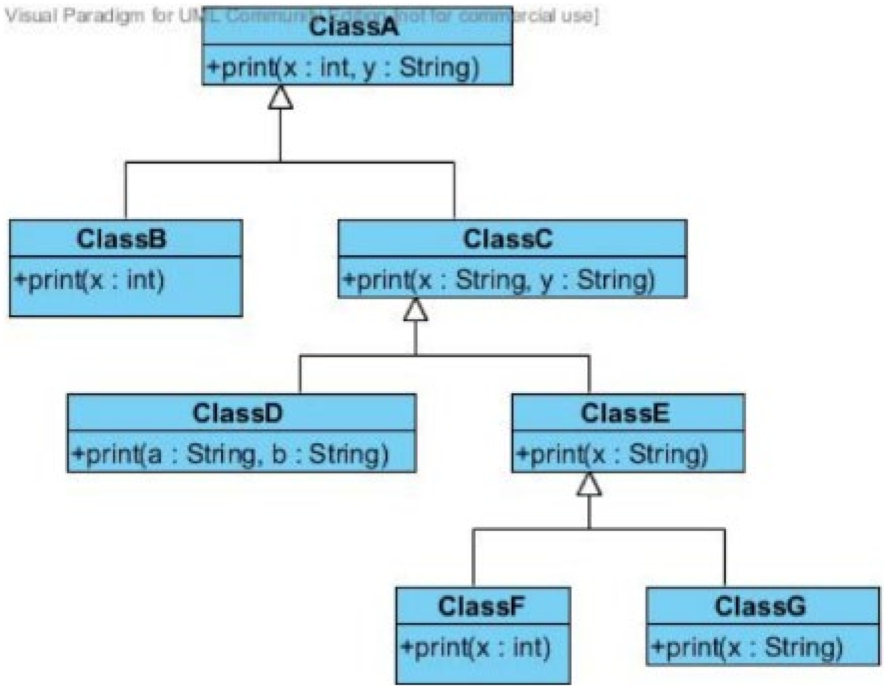
  // upcast ok (compile ok)

  ClassG g = (ClassG)a;

  // downcast ok (compile ok)

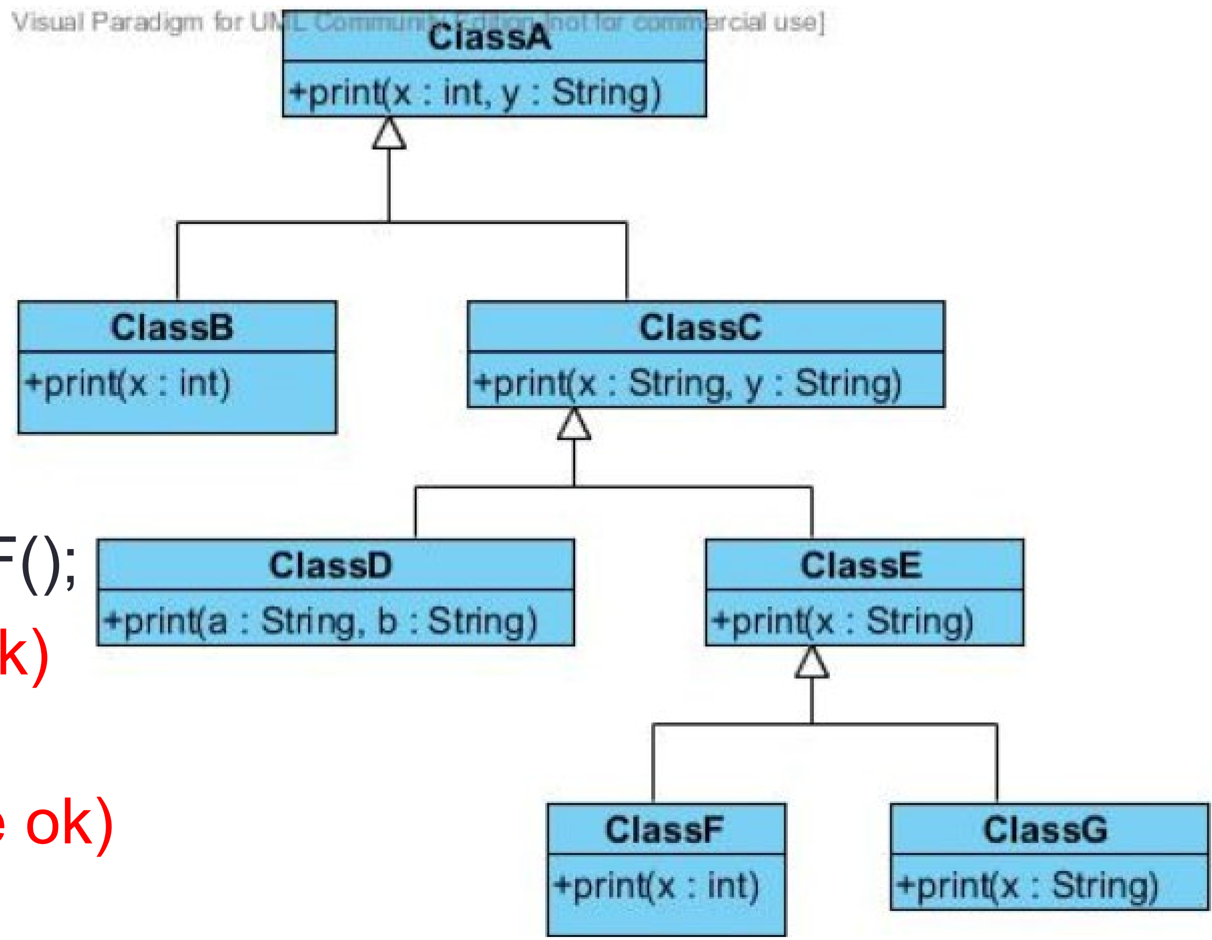
// RuntimeError : Object is ClassC

// cannot be cast to downcasting.G



g.print("hello");

//compile ok



- ClassA a = new ClassF();

// upcast ok, (compile ok)

ClassC f = (ClassC)a;

// downcast ok (compile ok)

f.print(88,"there");

// compile ok, inherit from ClassA. Runtime ok since a is ClassF object and ClassF to ClassC is upcasting

Q3. Benefits of Polymorphism

Q3

- Given the Java code for a Polygon class. Two subclasses, Rectangle and Triangle, are derived from Polygon class

```
public class Polygon {
    public enum KindofPolygon{POLY_PLAIN,POLY_RECT,POLY_TRIANG};
    protected String name;
    protected float width, height;
    protected KindofPolygon polytype;
    public Polygon(String theName,float theWidth,float theHeight){
        name = theName;
        width = theWidth;
        height = theHeight;
        polytype = KindofPolygon.POLY_PLAIN; }
    public KindofPolygon getPolytype() {
        return polytype; }
    public void setPolytype(KindofPolygon value) {
        polytype = value; }
    public String getName() { return name; }
    public float calArea() { return 0; }
    public void printWidthHeight( ) {
        System.out.println("Width = "+width+" Height = "+height);}
}
```

(i) Write the code for the Rectangle and Triangle subclass

```
public class Rectangle extends  Polygon {
    public Rectangle(String theName,float theWidth,float theHeight)
        super(theName, theWidth, theHeight) ;
        this.polytype = KindofPolygon.POLY_RECT;
    }
    public float calArea() { return width * height; }
}
```

```
public class Triangle extends Polygon {
    public Triangle(String theName,float theWidth,float theHeight{
        super(theName, theWidth, theHeight) ;
        this.polytype = KindofPolygon.POLY_TRIANG;}
    public float calArea() { return 0.5f * width * height; }
}
```

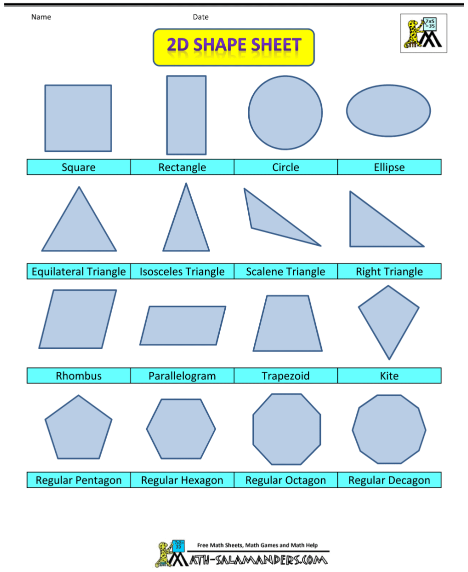
(ii) Write a TestPolygon class to have a overloaded method **printArea(....)** which will calculate and printout the area of the polygon type passed as argument, ie **printArea(Rectangle r)** and **printArea(Triangle t)**.

```
public class TestPolygon {
public static void printArea(Rectangle rect) {
float area = rect.calArea( );
System.out.println("The area of the Rectangle"
+ " is " + area);
}
public static void printArea(Triangle tri) {
float area = tri.calArea( );
System.out.println("The area of the Triangle"
+ " is " + area);
}
```

```
//the method for comparing the areas of two Rectangles
public static boolean equalArea(Rectangle fig1, Rectangle fig2){
return fig1.calArea() == fig2.calArea();
}

//the method for comparing the areas of a Rectangle and a Circle
public static boolean equalArea(Rectangle fig1, Circle fig2){
return fig1.calArea() == fig2.calArea();
}


//the method for comparing the areas of two Circles
public static boolean equalArea(Circle fig1, Circle fig2){
return fig1.calArea() == fig2.calArea();
}
```



256 combinations

Permutations

(iii) Write the main( ) function to demonstrate **static binding** of all printArea methods.[Hints : have overloaded printArea methods for each Polygon subclass].

What is the impact on the program when a new subclass of Polygon is introduced?

```java
public static void main(String[] args ) {
    Rectangle rect1 = new Rectangle("Rect1", 3.0f, 4.0f);
    printArea(rect1);  // static binding
    rect1.printWidthHeight();

    Triangle triang1= new Triangle("Triang1", 3.0f, 4.0f);
    printArea(triang1); // static binding
    triang1.printWidthHeight();
}
```

(iv) Repeat part (ii) for **dynamic binding** of **printArea( )**.

- [Hints : have a single printArea method, regardless of which Polygon subclass].

```
public class TestPolygon {
    public static void printArea(Polygon poly) {
        float area = poly.calArea( );
        System.out.println("The area of the "+
        poly.getPolytype() +" is "+area);
    }
    public static void main(String[] args ) {
        Rectangle rect1 = new Rectangle("Rect1", 3.0f, 4.0f);
        printArea(rect1);
        rect1.printWidthHeight();

        Triangle triang1= new Triangle("Triang1", 3.0f, 4.0f);
        printArea(triang1);
        triang1.printWidthHeight(); }
}
```

```java
public class FigureAbstractWhyGood {
public static void main( String[] args )
 {
Figure f1 = new Rectangle( "Red" , 10 , 10 );
Figure f2 = new Rectangle( "YELLOW" , 8 , 7 );
Figure f3 = new Circle( "Orange" , 7.8 );
Figure f4 = new Circle( "BLUE" , 6.2);

System.out.println("The two Figures f1 and f2 have the same area? " +
equalArea(f1,f2));
…
 }

//the method for comparing the areas of the two figures
public static boolean equalArea(Figure fig1, Figure fig2){
return fig1.findArea() == fig2.findArea();
}
}
```

One general method only

(v) Modify the **Polygon** code so that any of its subclasses **must** include a **calArea()** member method. Suggest reason(s) why this requirement would be appropriate in this case.

- Make the calArea method an abstract method and make Polygon class an abstract class. ie,

```
public abstract class Polygon {
        ....
        Public abstract float calArea();
}
```

- This will 'enforce' all derived classes of Polygon to implement its own calArea.
- It is not appropriate for Polygon class to have a default implementation as different polygons have different formula used for calculating area. Enforcing the implementation of the method ensures that calArea will be implemented appropriately for all Polygon subclasses.