# Object-Oriented Programming – Sample Exam

## Problem 2 – Geometry API

You are given an API containing some basic **3D geometry operations** – working with vectors, representing figures and their measures and so on. You are also given a FigureController, which executes operations coming from the standard input, over figures.

### Important Classes and Interfaces

The API contains these Interfaces:

* ILengthMeasurable – provides a method GetLength() for getting the length of a figure. Should be implemended by figure classes for which length is measurable (e.g. line segments).
* IAreaMeasurable – provides a method GetArea() for getting the area of a figure, similar to ILengthMeasurable.
* IVolumeMeasurable – provides a method GetVolume() for getting the volume of a figure, similar to IAreaMeasurable.
* IFlat – provides a method GetNormal(), returning a normal vector. Should be implemented by flat (plane) figures (e.g. triangle, rectangle, etc.). A normal vector is a vector perpendicular to the surface of the figure.
* ITransformable – provides method for doing linear transformations (rotate, scale, translate) on figures. All figures should implement ITransformable.

For working with vectors, the API has these classes:

* Vector – provides an abstract class for n-dimensional vectors, with a property for Magnitude (length) and a field for the components of the vector. Also has Normalization (making the vector with Magnitude = 1) and an indexer for access to the separate components.
* Vector3D – 3-dimensional vector (3 components) with sum and subtraction operators defined, as well as multiplication by number. The class also provides some static members for vector operations – cross product, dot product and angle between two vectors, as well as parsing a vector from a string and a ToString() returning the format in which a vector should be printed on the console.

For working with figures, the API has these classes:

* Figure – abstract class that provides the base functionality for all figures and implements ITransformable. It uses a list of Vector3D elements, defining the positions of vertices of the figure (or important locations in the figure). The Figure class should be inherited by any figure, which needs to be controlled by the FigureController.
* FigureController – class for reading commands from the standard input and executing them on figures. The objects of the FigureController class keep a currentFigure field, on which they execute the incomming commands.

The code you will get will have the API and an instance of the FigureController class in the Main() method. It can handle reading input and writing output in the expected format (will be explained later), but is not complete and you will have to complete it.

Study the classes to get a better understanding of the API.

### Commands

Commands are strings, which are executed by the FigureController. Commands consist of several "words" which describe the command. The "words" are these types:

* Command name – a string identifying the command
  + Examples:
    - center
    - rotate
    - triangle
* Command vector argument – a string representing a 3D vector, which can be parsed by Vector3D.Parse()
  + Example: (10,-5,0.3)
* Command scalar (number) argument – a string representing a number
  + Example: -5.3

All "words" in a command are separated by whitespaces and no word can contain whitespaces in it.

There are 3 types of commands:

* Figure creation command – creates a new figure and sets it as the current figure for the FigureController.
  + Format: [figureName] [figureVector1] [figureVector2] [figureVector…]
  + Examples:
    - triangle (0,0,0) (1,1,1) (2,0,0)
    - segment (1,13,2.3) (-4,10,0)
* Figure instance command – does operations on the current figure in the FigureController
  + Format: [operationName] [arguments…]
  + Examples:
    - rotate (0,0,0) 45 – rotates the current figure by 45 degrees about (0,0,0)
    - center – prints the vector, describing the center of the current figure
* End command – signals the end of the operations on the current figure
  + Format: end

Here's a list of all commands which are currently implemented in the API:

* translate (*vectorX*,*vectorY*,*vectorZ*) – translates the current figure with the given *vector*
* rotate (*centerX*,*centerY*,*centerZ*) degrees – rotates the current figure about the *center* by the given number of degrees. Rotation is only in the XY plane.
* scale (centerX,centerY,centerZ) factor – scales all vertices of the current figure away from the *center* by the given factor
* center – prints on the console the center of the figure as a vector in the format (x,y,z)
* measure – prints the "primary measure" of the current figure on the console as a number (e.g. 43). The primary measure for a line segment is its length, for a plane figure – its area, and for a 3D figure (e.g. cube) – its volume.
* vertex (x,y,z) – creates a "single vertex" figure and sets it as the current figure at coordinates the given x,y,z
* segment (ax,ay,az) (bx,by,bz) – creates a "line segment" figure and sets it as the current figure, with a first vertex at the given ax,ay,az and a second vertex at the bx,by,bz
* triangle (ax,ay,az) (bx,by,bz) (cx,cy,cz) – creates a triangle and sets it as the current figure, with vertices at the given coordinates

### Tasks

You are advised to use everything you can from the existing API to complete the tasks that follow. You are not allowed to edit the Main() method or any provided by the API classes.

* Implement parsing of a command to create a **circle**:
  + The circle should be able to calculate its **area**
  + The circle should be able to **return a vector perpendicular to its surface**.
  + Circles will always lay in the XY plane
  + The radius of a circle doesn't scale
  + The **area** of the circle is its "**primary measure**"
  + Format: **circle (centerX,centerY,centerZ) radius**
  + Example: circle (0,1,-2) 5 – creates a circle with radius 5 and center the coordinates (0,1,-2)
* Implement parsing of a command to create a **cylinder**:
  + The cylinder should be able to calculate its **area** (the area of its walls)
  + The cylinder should be able to calculate its **volume**
  + The **volume** of a cylinder is its **primary measure**
  + The radius of a cylinder doesn't scale
  + Format: **cylinder (bottomX,bottomY,bottomZ) (topX, topY, topZ) radius** – creates a cylinder by making a base circle with a center (bottomX, bottomY, bottomZ) and the given radius, a top circle with a center (topX, topY, topZ) and the given radius and connecting them
  + Example: cylinder (5,-5,3) (5,-5,6) 7 – creates a cylinder with a base circle at (5,-5,3) and top circle at (5,-5,6), both with a radius of 7
* All **currently defined commands must work** for the new and the old figures.
* Implement an “**area**” command, which, if the figure can calculate its area, prints on the console the area of the figure as a number, and if the figure can not calculate its area, prints “undefined”.
* Implement a “**volume**” command, which, if the figure can calculate its volume, prints on the console the volume of the figure as a number, and if the figure can not calculate its volume, prints “undefined”.
* Implement a “**normal**” command, which, if the figure can calculate a its normal vector, prints on the console the normal vector, using the ToString of the Vector3D class, and if the figure can not calculate its normal vector, prints “undefined”. The **normal** vector is a vector **perpendicular to the surface** of the figure and has a **Magnitude of 1**.

#### Input

The input for the commands is read from the console.

On the first line the number of figures **N** that are going to be created is specified. N will be **between 1 and 20**.

On the next line there is a command for creating a figure, and after that on each line there is a single command related to the figure, until a line with the command “end” is reached. This is repeated for each of the N figures.

**The input is currently handled by the Main method through an instance of the** FigureController **class**. You should think only about parsing the new commands and using the FigureController’s methods for the old commands.

Note: **all numbers and coordinates can be floating-point numbers**. Using a 64-bit floating point is advised. All **numbers in the output must be rounded to the second digit after the decimal point**.

#### Output

Not all commands require output – for example translate, rotate, scale and creation of figures do not print anything on the console. Other commands require output in the form of either a **number** or a **vertex**. Commands that require printing a **number** must just print a number on a **new line**. Commands that print a **vertex** must print the vertex **through** its ToString() method on a **new line**.

#### Example

|  |  |
| --- | --- |
| **Input** | **Output** |
| **3**  **triangle (0,-1,0) (0,1,0) (1,0,0)**  **area**  **translate (1,1,1)**  **scale (1,1,1) 2**  **area**  **end**  **triangle (0,0,0) (1,-1,0) (2,0,0)**  **volume**  **measure**  **end**  **circle (0,0.5,0) 4.5**  **area**  **normal**  **end** | **1.00**  **4.00**  **undefined**  **1.00**  **63.62**  **(0.00,0.00,1.00)** |