Instructions to Candidates

This examination accounts for 50% of the total marks for the subject.

This examination totals 120 marks (or 1 mark per minute).

Answer all questions: 1 to 7.

Marks for each question are shown.

This examination is closed book.

Calculators are not permitted.

Question 1

Each of the following questions has a concise answer.

(a) Write a one-line comment in VRML.
(b) What is 180° in radians?
(c) What kind of interpolation is implemented by VRML interpolator nodes?
(d) What is the name of the tool for compressing VRML?
(e) Which fields of the XHTML img tag are compulsory?
(f) What is the name of the VRML node that specifies the colour of a shape?
(g) Which VRML keyword is used for naming nodes?
(h) Which VRML keyword is used for connecting an output from one node, to the input of another?
(i) Which VRML node specifies different versions of a shape, according to the distance from the viewer?
(j) Which field of the IndexedFaceSet node controls smooth shading between neighbouring polygons?

\[(1+1+1+1+1+1+1+1 = 10 \text{ marks})\]
Question 2

Consider the following VRML source:

```
#VRML V2.0 utf8
Shape
{  
geometry Cone {  
    appearance Appearance
    {  
      material Material { diffuseColor 1.0 1.0 1.0 }
    }
  }
}
```

(a) Describe what this would look like in a VRML viewer.
(b) Describe the purpose of the Shape node.
(c) Describe the purpose of the Appearance node.
(d) Give the VRML source for a green box with a width of 5 units, a height of 4 units, and a depth of 1 unit. Include a header and appropriate comments.

\[ 3+2+2+8 = 15 \text{ marks} \]

Question 3

VRML is designed for web-based, real-time interactive three dimensional content.

(a) Describe the fields of the VRML Material node, including diagrams as appropriate.
(b) Describe three of the file formats available for VRML textures and the advantages and disadvantages of each.
(c) Describe the purpose of the VRML LOD node. Include a description of the fields of the LOD node: center, range and level.
(d) Describe the purpose of the VRML Inline node.

\[ 6+6+6+2 = 20 \text{ marks} \]
Question 4

The VRML Transform node is used for translating, scaling and rotating shapes in three dimensions. For the following illustrations give the required VRML Transform, omitting the children. Assume a right-handed co-ordinate system, with the z axis pointing out of the page.

(a)

(b)

(c)

(d)

(3+3+3+6 = 15 marks)
Question 5

Transformations in VRML may be nested, forming a hierarchy of shapes and relative transformations between them. Consider the following example of a robot arm consisting of two joints connecting two segments:

```
DEF SHOULDER Transform
{
    children
    [
        DEF UPPER_ARM Shape { ... }
        DEF ELBOW Transform
        {
            children
            [
                DEF LOWER_ARM Shape { ... }
            ]
        }
    ]
}
```

(a) Which VRML nodes are affected by applying a rotation to the ELBOW node?

(b) The pitch of the arm can be adjusted by rotation around the x axis at the shoulder joint. Give the VRML OrientationInterpolator node for an animation as follows:

![Graph showing angle vs. time](image)

(c) Using the following time sensor, write the remaining VRML source for animating the arm. You may assume that the time sensor is triggered elsewhere.

```
DEF TIMER TimeSensor
{
    cycleInterval 4.0
    loop FALSE
}
```

(d) Give VRML code for an extended hierarchy which includes a wrist joint and hand.
You need not include the fields of Shape nodes.
You need only include the children field of each Transform.

\[2 + 5 + 4 + 4 = 15 \text{ marks}\]
Question 6

Some shapes such as spheres, cones and cylinders are built into VRML. Others may be constructed from lines and faces, as necessary. Consider the following two dimensional shape:

Assume that the object is flat, that is, z = 0.

(a) Write the VRML code for an IndexedLineSet node.
   Include the coord and coordIndex fields.

(b) Write the VRML code for an IndexedFaceSet node.
   Include the coord, coordIndex, ccw, convex and solid fields as necessary.

(c) Are the face(s) in your IndexedFaceSet convex?
   Explain why, or why not.

(d) Explain your choice of TRUE or FALSE for the solid field of your IndexedFaceSet node.

(e) Give the coordIndex field for the same IndexedFaceSet using only convex faces.

\[8 + 8 + 5 + 4 + 5 = 30 \text{ marks}\]
Question 7

The VRML ElevationGrid node is commonly used for modelling terrains. The elevation is specified for each point in a 2D grid. The faces connecting these sampled elevations are automatically built by the VRML browser rather than being individually specified in the VRML file.

(a) Describe the relative advantages and disadvantages of the ElevationGrid node compared to the IndexedFaceSet node.

(b) The following map shows part of Wilson’s Promontory National Park. Contour lines are shown at each multiple of 20m of elevation. The thicker contours indicate multiples of 100m of elevation. The dashed line indicates the walking track. The coastline and creek beds are drawn in blue.

(i) What is the minimum elevation of this terrain?
(ii) What is the maximum elevation of this terrain?
(iii) Give the VRML ElevationGrid node for a $4 \times 4$ square sample grid of the terrain.

(c) What is the relationship between the number of samples in the $x$ and $z$ directions and the frame rate of the VRML browser? (Hint: What is the relationship between the sample rate and the number of polygons rendered?)

$$4 \div (1+1+6) + 3 = 15 \text{ marks}$$

**THE END**