Reg. No. | | | | | | | | | | |

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

I SEMESTER M.TECH (CAAD)

END SEMESTER EXAMINATION – NOV. 2018

SUBJECT: GEOMETRIC MODELLING FOR CAD (MME 5103)

REVISED CREDIT SYSTEM

Time: 3 Hours **Max. Marks: 50**

Note: (i) Missing data, if any, may be appropriately assumed
(ii) Draw sketches as applicable
(iii) Assumptions made must be clearly mentioned

1A. With neat sketches explain data structure and different types of databases. 04

1B. Explain the objectives of Geometric Modelling for CAD. 02

1C. A rectangle's corners are defined by the position vectors (3, 2), (8, 2), (8, 5) and (3, 5). It is required to scale it about the corner point (3, 2) such that the rectangle appears like a square of edge 5 units. The edges of the final square must be parallel to coordinate axes.

(i) List the sequence of transformations involved and write their corresponding transformation matrices

(ii) Determine the concatenated transformation matrix for achieving the desired transformation. 04

2A. A triangle ABC is projected on the *x-y* plane such that a unit vector along the direction of projection is defined by $0.442\hat{i} - 0.885\hat{j} + 0.147\hat{k}$. If the coordinates of the vertices of the triangle are A = (2, 3, 5), B = (5, 6, 8) and C = (4, 9, 4), compute the coordinates of the vertices of the projected triangle. 03

2B. A closed B-Spline curve is defined by 6 control points. The order of the curve is defined by the parameter *k* whose value is 4.

(i) Sketch the curve and write the characteristic features of this curve.

(ii) Express the parametric equations of all segments in matrix form. 03

2C. Two analytical curves C_1 and C_2 intersect each other at two points: V and A. The vertices of the two curves coincide at V. The parametric equations of the curves are given in the table below. Compute the coordinates of the intersection point at A. 04

Curve #	Parametric equations	Range
C_1	$x = 5 + 8u$ $y = 4 + 4u^2$	$-\infty \leq u \leq +\infty$
C_2	$x = 5 + 4v^2$ $y = 4 + 8v$	$-\infty \leq v \leq +\infty$

3A. An approximation open curve with global control is defined by five control points. It is required to sweep it linearly by a distance '*d*' along a direction defined by the unit vector $l\hat{i}+m\hat{j}+n\hat{k}$, so as to obtain a 3D surface in space. Deduce the parametric equations of the curve and the swept surface. 03

3B. Write the parametric equations of the following surfaces in matrix form:

(i) Hermite cubic surface patch

(ii) Cubic-quartic Bezier surface patch

(iii) NURBS surface patch 03

3C. A synthetic curve parametrized in u has the position vectors at its start and end points as $\overrightarrow{p_o}=2\hat{i}+3\hat{j}+5\hat{k}$ and $\overrightarrow{p_1}=6\hat{i}+7\hat{j}+10\hat{k}$ respectively.

(i) The tangent vectors to the curve at these points are given as $\overrightarrow{p_o^1}=1\hat{i}+2\hat{j}+6\hat{k}$ and $\overrightarrow{p_1^1}=-1\hat{i}+2\hat{j}+4\hat{k}$ respectively. Compute the position vectors of the points on the curve at 30% and 70% of the curve length.

(ii) If the magnitude of the tangent vector at start is tripled, and that of the tangent vector at end remains the same, compute the position vectors of the points on the curve at 30% and 70% of the curve length. 04

4A. A Bilinear surface patch is defined by the position vectors of its four corner points: $p(0, 0) = (0, 0, 10)$, $p(1, 0) = (10, 0, 10)$, $p(0, 1) = (0, 0, 0)$ and $p(1, 1) = (10, 10, 0)$. Compute the coordinates of the points on the surface at (i) $u = 0.3$ and $v = 0.7$, and (ii) $u = 0.8$ and $v = 0.4$. 03

4B. An approximation curve, with global control and parametrized in u, is circularly swept about a line collinear with the z axis. The curve is defined by the position vectors $\overrightarrow{p_0}=0\hat{i}+0\hat{j}+2\hat{k}$, $\overrightarrow{p_1}=3\hat{i}+0\hat{j}+2\hat{k}$, $\overrightarrow{p_2}=5\hat{i}+0\hat{j}+6\hat{k}$, $\overrightarrow{p_3}=2\hat{i}+0\hat{j}+7\hat{k}$ and $\overrightarrow{p_4}=3\hat{i}+0\hat{j}+10\hat{k}$ respectively, where $\hat{i}$, $\hat{j}$ and $\hat{k}$ are the unit vectors along the x, y and z axes.

(i) Compute the position vector of a point on the curve at $u = 0.6$.

(ii) Compute the position vector of a point on the circularly swept surface at $u = 0.6$ and $\theta = +30^\circ$ 03

4C. With respect to solid modelling,

(i) List and explain the operators used to construct a solid model using the Boundary representation (B-Rep) approach.

(ii) Explain the principle and objectives of the Octree and the Voxel approaches of solid representations. 04

5A. With respect to rasterizing an ellipse using the mid-point algorithm,

(i) Explain the reason for incrementing x coordinate in every iteration for region 1 and decrementing y coordinate in every iteration for region 2.

(ii) Deduce the condition for shifting from region 1 to region 2. 03

5B. A circle with center positioned at (5, 8) and radius 9 units is to be rasterized on a CRT display terminal. Evaluate the best pixels to be plotted using the Bresenham's circle algorithm. 03

5C. Deduce an expression for calculating the mass moment of inertia of a solid model about the z axis. 02

5D. List the steps of the z-buffer algorithm used for hidden edge/surface removal. 02

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