# KUMARAGURU
## college of technology
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## B.E DEGREE EXAMINATIONS: MAY 2018

(Regulation 2015)

Sixth Semester

## MECHANICAL ENGINEERING

U15MET602: Finite Element Analysis

## COURSE OUTCOMES

**CO1:** Solve problems by applying standard finite element techniques.
**CO2:** Analyze 1-D finite elements and to build the stiffness matrix.
**CO3:** Examine 2-D finite element continuum for structural applications.
**CO4:** Solve 1-D and 2-D heat transfer problems using finite element approach.
**CO5:** Apply axisymmetric formulation for specific applications.
**CO6:** Make use of finite element principles in isoparametric applications.

**Time: Three Hours**          **Maximum Marks: 100**

### Answer all the Questions:-
### PART A (10 x 1 = 10 Marks)

1. Match list I (weighted residual methods) with list II (Residual functions) and select the correct answer using the codes given below.    CO1 [K$_2$]

| List I | List II |
| --- | --- |
| A. Point collocation method | i. Integral of the weighted square of the residual over the domain is minimum. |
| B. Subdomain collocation method | ii. Residual function is zero |
| C. Least square method | iii. Integral of residual function over the domain is zero |
| D. Galerkin's method | iv. Trial function is considered as the weighting function |

| | A | B | C | D |
| --- | --- | --- | --- | --- |
| a) | ii | iii | i | iv |
| b) | iii | ii | iv | i |
| c) | ii | i | iii | iv |
| d) | i | ii | iii | iv |

2. Weighted residual method is useful for solving _____    CO1 [K$_2$]

   a) Non-structural problems      b) Structural problems

   c) Vibration Analysis      d) Fluid - Flow Problems

3. Consider the following statements.                                                  CO2 [K₂]
    1. A traction force is a distributed force acting on every elemental volume.
    2. A body force is a force that acts on surface of the body.
    3. Self-weight is considered as a point load.
    4. Any structure can be discretized infinite number of times.
   Which of these statements are correct?

   a) i and ii                                   b) Only ii

   c) Only i                                     d) Only iv

4. Consider the following statements.                                                  CO3 [K₂]
    1. A matrix which has non-zero coefficients located on or near the main diagonal is called
   Banded matrix.
    2. A stiffness matrix is a skew symmetric matrix
    3. A stiffness matrix is a symmetric matrix
    4. The determinant of a stiffness matrix is non-zero
   Which of these statements are correct?

   a) 1,3                                        b) 3,4

   c) 2,4                                        d) 2,3

5. Assertion (A): Constant strain triangle (CST) is a three noded triangular element with six   CO3 [K₂]
   degrees of freedom.
   Reason (R)   : Linear strain triangle (LST)  is a ten noded triangular element

   a) Both A and R are Individually true and     b) Both A and R are Individually true but

      R is the correct explanation of A              R is not the correct explanation of A

   c) A is true but R is false                   d) A is false but R is true

6. Assembled stiffness matrix after applying boundary conditions is not a                CO4 [K₂]

   a) Square                                     b) Banded

   c) Symmetric                                  d) Singular

7. Sequence the general steps of the finite element analysis                            CO4 [K₂]

   (i) Derivation of element stiffness matrix and equation (ii) Applying boundary conditions (iii)

   Computation of the element stresses and strains     (iv) Discretization

   a) i – iv – iii - ii                          b) ii – iv – i - iii

   c) iv – i – ii - iii                          d) iv – iii – ii - i

8. The element stiffness matrix for the axisymmetric element is                         CO5  [K₂]

   a) $tw_1w_2[J][B]^T[D][B]$                    b) $tA[B]^T[D][B]$

   c) $A[B]^T[D][B]$                             d) $2\pi rA[B]^T[D][B]$

9. Assertion (A): The sum of the shape function is equal to zero.                       CO5 [K₂]

   Reason (R)  : The shape function has unit value at its own nodal point and zero value at other
                 nodal point.

a) Both A and R are Individually true and R is the correct explanation of A
b) Both A and R are Individually true but R is not the correct explanation of A
c) A is true but R is false
d) A is false but R is true

10. In shape function the field variables and geometry transformation are in equal    CO6 [K$_2$]

a) Subparametric elements    b) Superparametric elements

c) Isoparametric elements    d) parametric elements

### PART B (10 x 2 = 20 Marks)
### (Answer not more than 40 words)

| | | | |
|---|---|---|---|
| 11. | Mention some properties of element stiffness matrix. | CO1 | [K$_2$] |
| 12. | List any two reasons to use polynomial type of interpolation functions. | CO1 | [K$_2$] |
| 13. | State the assumptions are made while finding the forces in truss. | CO2 | [K$_2$] |
| 14. | What are the characteristics of shape function? | CO2 | [K$_2$] |
| 15. | Write down the strain – displacement matrix for CST element. | CO3 | [K$_2$] |
| 16. | Write down the finite element equation for one dimensional heat conduction with free end convection. | CO4 | [K$_2$] |
| 17. | What are the condition for a problem to be axisymmetric triangular element? | CO5 | [K$_2$] |
| 18. | Write down the shape function for an axisymmetric triangular element. | CO5 | [K$_2$] |
| 19. | What is the purpose of Isoparametric elements? | CO6 | [K$_2$] |
| 20. | Define superparametric elements. | CO6 | [K$_2$] |

### Answer any FIVE Questions:-
### PART C (5 x 14 = 70 Marks)
### (Answer not more than 300 words)

**Q.No. 21 is Compulsory**

21. The differential equation of a physical phenomenon is given by:    CO1 [K$_2$]
$(d^2y/dx^2) + 500 x^2 = 0$, $0<x<1$
Trail function, $y = a_1(x - x^4)$
Boundary conditions are $y(0) = 0$, $y(1) = 0$
Calculate the value of the parameter $a_1$ by the following methods:
i) Point collocation, ii) Subdomain collocation, iii) Least squares, iv) Galerkin method

22. List and briefly describe the general steps of the finite element method.    CO1 [K2]

23. For the plane truss shown in figure 1, determine the horizontal and vertical displacements of nodes. All the elements have E = 201 GPa and A = 4 x 10$^{-4}$ m$^2$.    CO2 [K$_2$]

Fig.1.

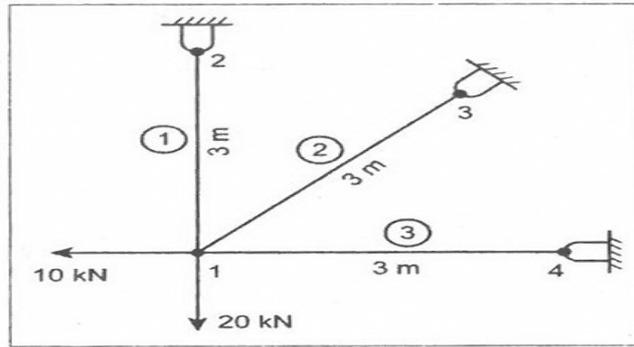| 24. | Derive the shape function for the constant strain triangular element. | CO3 | [K₃] |

24. Derive the shape function for the constant strain triangular element. CO3 [K$_3$]

25. A furnace wall is made up of three layers, inside layer with thermal conductivity 8.5 W/mK, the middle layer with thermal conductivity 0.25 W/mK, the outer layer with conductivity 0.08 W/mK. The respective thickness of the inner, middle and outer layer is 25 cm, 5 cm and 3 cm respectively. The inside temperature of the wall is 600 °C and outside of the wall is exposed to atmospheric air at 30 °C with heat transfer coefficient of 45 W/m$^2$K. Determine the nodal temperatures. CO4 [K$_2$]

26. For the element shown in figure 2, determine the stiffness matrix. Take E = 200 GPa and poisons ratio ($\mu$) = 0.25. The co-ordinates shown in figure 2 are in millimeters. CO5 [K$_2$]
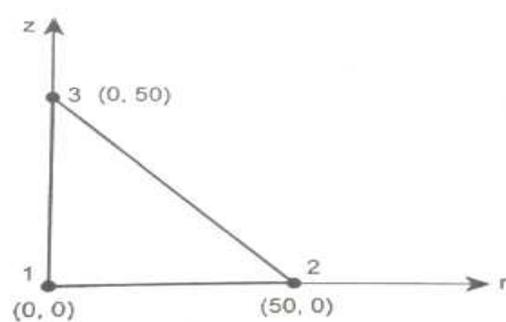


Fig. 2

27. Integrate the function f(r) = 1 + r + r$^2$ + r$^3$ between the limits -1 and +1 using, CO6 [K$_3$]

   i.   Exact method.

   ii.   Gauss integration method and compare the two results.

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