



BITS Pilani

Dubai Campus

SECOND SEMESTER 2012- 2013

III Year Mechanical
Comprehensive Examination
Weightage: 35%

ME C382 Computer aided design
Marks: 70

Date: 8.6.13
Time: 180 min.

Answer all Questions
Assume suitable data, if required.

1. Briefly explain the following with neat sketch

- a. Laminated object manufacturing [5]
b. Ladder FMS layout [5]

2. a. Determine the surface area traced on rotation about x axis by the curve defined by the following parametric equations. [5]

$$x(t) = 4t \\ y(t) = \sqrt{8}t + 2, \quad 0 \leq t \leq 1$$

- b. A cubic Bezier curve is defined by the control points (1,0,2), (2,0,3), (6,0,4) and (7,0,2). Find the surface of revolution obtained by revolving the curve about Z axis and calculate the point on the surface at $t = 0.4$ and $\theta = \pi/4$ [5]

3. a. Find the tangent vector and slope of a parametric parabola in X – Y plane at $u=0.5$ when the focal distance is 30 mm and $\alpha=20^\circ$. [5]

- b. For points $A=[1,3]$ and $B=[5, 1]$ with corresponding slopes 60° and 30° , write the formulation of Hermite cubic spline. [5]

4. a. Check the regularity for the following operations of Fig. 1.

- (i) $A \cup B$, (ii) $A \cap B$, (iii) $A \cup C$, (iv) $A \cap C$ [5]

- b. Check the validity of the model shown in Fig. 2 using suitable law. [5]

5. a. Consider a triangle with vertices $A(2,2,0)$, $B(6,2,0)$ and $C(4,6,0)$. Determine the position of the triangle after scaling 3.5 times bigger about its centroid using proper transformation procedure. [5]

- b. Consider a line with the following vertices; $A (1,3,4)$ and $B(3,6,4)$. The line is rotated ccw 45° about Y axis. When the line is projected from $Z=10$, determine the position of line on the viewing plane. [5]



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6. Consider a specimen as shown in Fig.3. Both ends are fixed and $P_1=1000N$ and $P_2=2000N$. Determine the nodal displacements and elemental strains using direct stiffness approach. The diameters of the sections are 20, 10 and 20mm respectively. The lengths of the sections are 15, 20 and 15mm. $E=200GPa$. [10]
7. Consider the structure shown in Fig.4. Take $E=200GPa$ & Load =2000N. Assume circular cross section for the structure and determine the average diameter for each section. Top most surface is fixed and the load is acting on the free end. Using potential energy minimization technique, determine the nodal displacements. [10]

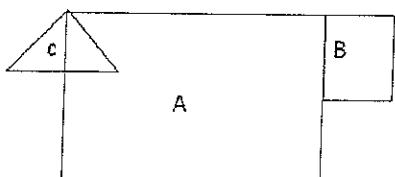


Fig. 1

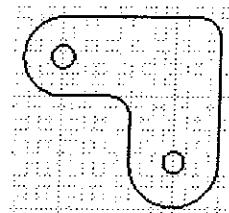


Fig. 2

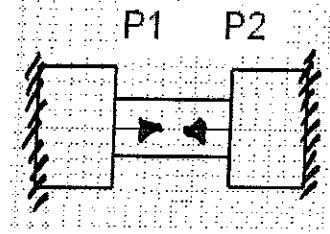


Fig. 3

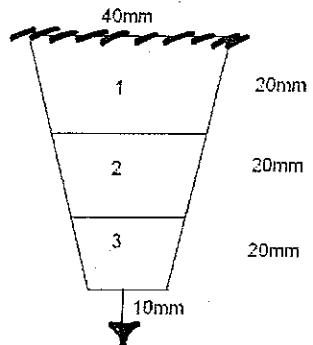


Fig. 4

Hermite cubic spline equation:

$$P(t) = [t^3 \quad t^2 \quad t \quad 1] \begin{pmatrix} 2 & -2 & 1 & 1 \\ -3 & 3 & -2 & -1 \\ 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} P(0) \\ P(1) \\ P'(0) \\ P'(1) \end{pmatrix}$$

Bezier cubic curve:

$$P(t) = [t^3 \quad t^2 \quad t \quad 1] \begin{pmatrix} -1 & 3 & -3 & 1 \\ 3 & -6 & 3 & 0 \\ -3 & 3 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} V_0 \\ V_1 \\ V_2 \\ V_3 \end{pmatrix}$$

-----All the best -----



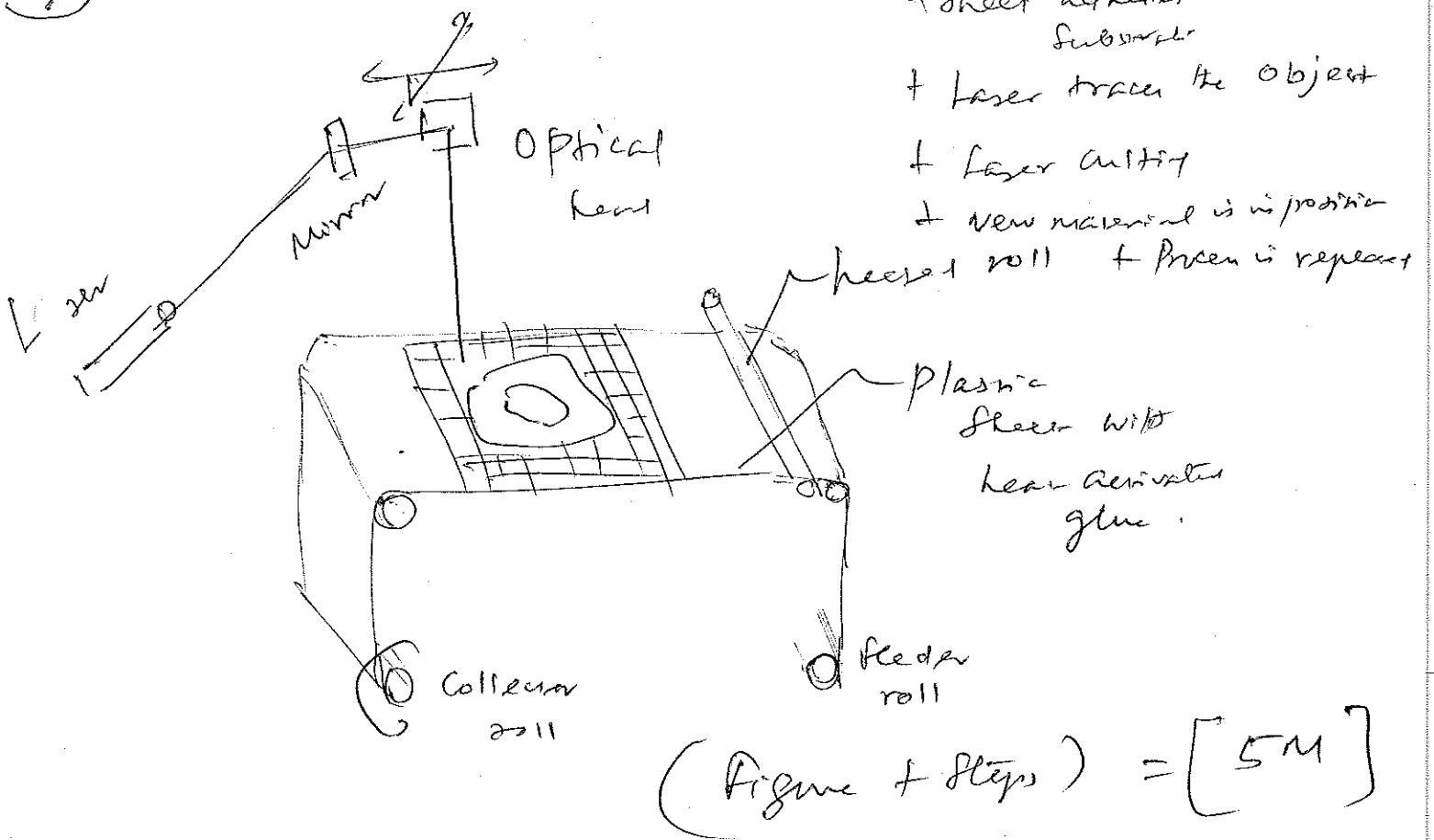
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Comprehensive Examination

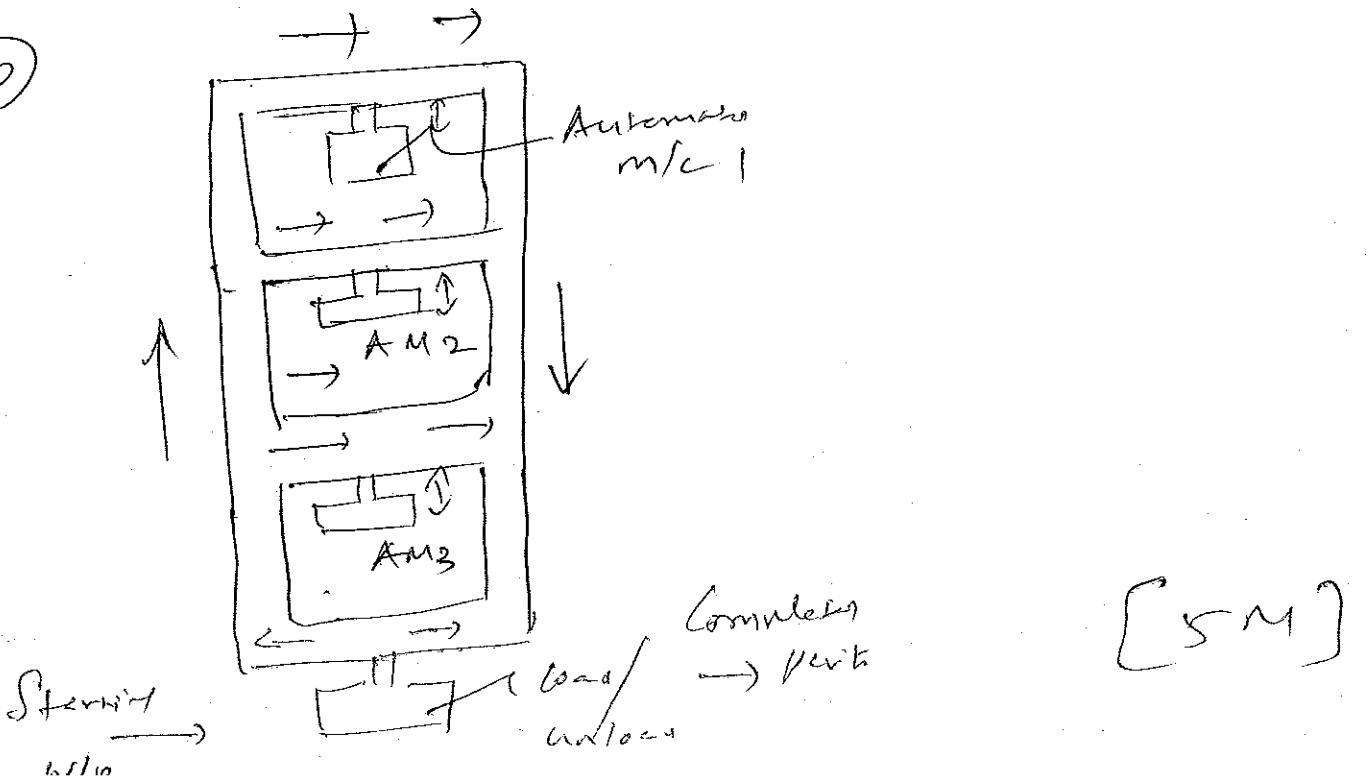
Solutions

FN

① a



② b



$$\textcircled{2} \textcircled{a} \quad \int 2\pi y \, ds \quad ds = \sqrt{x'(t)^2 + y'(t)^2}$$

$$\int_0^1 2\pi (\sqrt{t+2}) \sqrt{4^2 + \sqrt{t+2}^2} \cdot dt$$

$$= 33.5\pi \quad [5m]$$

B \textcircled{b}

$$\beta(t, \theta) = \begin{bmatrix} 0.4^3 & 0.4^2 & 0.4 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} -1 & 3 & -3 & 1 \\ 3 & -6 & 3 & 0 \\ -3 & 3 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix} \times$$

$$\begin{bmatrix} 1 & 0 & 2 & 1 \\ 2 & 0 & 3 & 1 \\ 6 & 0 & 4 & 1 \\ 7 & 0 & 2 & 1 \end{bmatrix} \times \begin{bmatrix} \cos \theta & \sin \theta & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{pmatrix} 0.605 & 0.605 & 0.605 & 1 \end{pmatrix}. \quad [5m]$$

(3) (a)

$$\frac{dp}{du} = [2 \times 30 \times 0.5 \times \cos 20^\circ - \\ 2 \times 30 \times \sin 20^\circ, \\ 2 \times 30 \times 0.5 \sin 20^\circ + 2 \times 30 \times \cos 20^\circ]$$

$$= [(28.19 - 20.52), (10.26 + 56.38)] \\ = (7.67, 66.64)^\circ$$

$$\text{Slope} = \frac{dy}{dx} = \left(\frac{66.64}{7.67} \right) = 8.72 \quad \checkmark$$

$$\tan^{-1} 8.72 = \underline{\underline{83.45}}^\circ \quad \checkmark$$

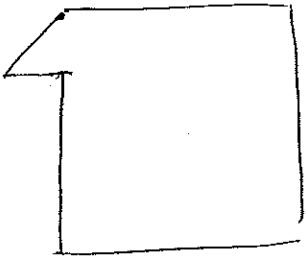
$$(5) \begin{bmatrix} t^3 & t^2 & t & 1 \end{bmatrix} \begin{bmatrix} 2 & -2 & 1 & 1 \\ -3 & 3 & -2 & -1 \\ 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} 1 \\ 5 \\ \cos 60^\circ \\ \cos 70^\circ \end{bmatrix}$$

$$x(t) = -6.67t^3 + 10.13t^2 + 0.5t + 1 \quad \checkmark$$

$$y(t) = 5.37t^3 + 8.27t^2 + 0.87t + 3$$

[5m]

(X) (A)



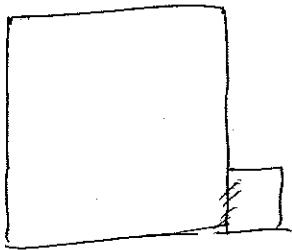
(iii)

Regular



(iv)

Regular



(i)

Regular

1

(ii)

Irregular.

[5 M]

(b)

$$V - E + F - (L - F) - \cancel{X}(S - a) = 0$$

$$V = 10, E = 10, F = 1,$$

$$S = 1,$$

~~Not~~ valid

[5 M]

(c)

(a)

$$P^* = [T]^t [+]^s [T]^{-t} [P]$$

$$[T]^t = \begin{bmatrix} 1 & 0 & dx \\ 0 & 1 & dy \\ 0 & 0 & 1 \end{bmatrix}$$

$$[T]^{-t} = \begin{bmatrix} s_x & 0 & 0 \\ 0 & s_y & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$P^* = \begin{bmatrix} -3 & 11 & 4 \\ -1.3 & -1.7 & 12.7 \\ 0 & 0 & 0 \end{bmatrix}$$

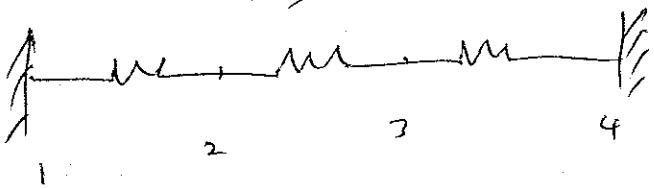
[5 M]

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & -1/d & 0 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

$$T_R = \begin{bmatrix} \cos \theta & 0 & \sin \theta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin \theta & 0 & \cos \theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$P^* = \begin{bmatrix} 3.50 & 4.95 \\ 7 & 6 \\ -0.212 & -0.07 \end{bmatrix} \quad \begin{array}{l} 4.4, 3.8 \\ 5.3, 6.4 \\ [5m] \end{array}$$

$$\begin{array}{cc} 1000 & -2000 \\ \rightarrow & \leftarrow \end{array}$$



$$k_1, k_3 = 4.8 \times 10^9 \text{ N/m}$$

$$k_2 = 0.785 \times 10^9 \text{ N/m}$$

$$\begin{bmatrix} k_1 + k_2 & -k_2 \\ -k_2 & k_2 + k_3 \end{bmatrix} \begin{bmatrix} q_2 \\ q_3 \end{bmatrix} = \begin{bmatrix} 1000 \\ -2000 \end{bmatrix}$$

$$q_2 = \frac{0.14 \times 10^{-9} \text{ m}}{-6} \approx 1.4 \times 10^{-9} \text{ m}$$

$$q_3 = \frac{-0.37 \times 10^{-9} \text{ m}}{-6} \approx 3.7 \times 10^{-9} \text{ m}$$

$$\begin{array}{l} E_1 = 9.6 \times 10^{-6} \\ E_2 = -2.4 \times 10^{-5} \\ E_3 = 2.5 \times 10^{-5} \\ [10 \text{ m}] \end{array}$$

(X)

$$d_1 = 35 \quad l_1 = l_2 = l_3 = 20 \text{ mm}$$

$$d_2 = 25$$

$$d_3 = 15 \text{ mm}$$

$$A_1 / 9.62 \times 10^{-4} \text{ m}^2$$

$$A_2 / 4.9 \times 10^{-4} \text{ m}^2$$

$$A_3 / 1.76 \times 10^{-4} \text{ m}^2$$

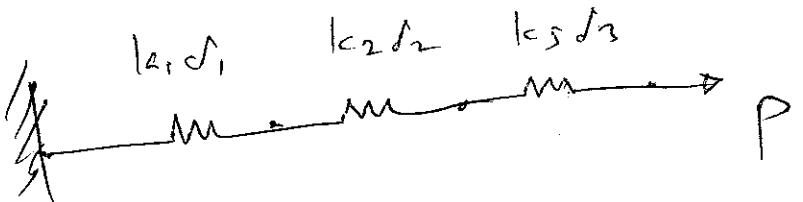
$$k_1 = 9.62 \times 10^9 \text{ N/m}$$

$$k_2 = 4.9 \times 10^9 \text{ N/m}$$

$$k_3 = 1.76 \times 10^9 \text{ N/m}$$

$$\frac{1}{2} k_1 d_1^2 + \frac{1}{2} k_2 d_2^2 + \frac{1}{2} k_3 d_3^2 - P \times q_3 = \underline{\underline{P.E}}$$

$$\frac{\partial \pi}{\partial q_2} = 0,$$



$$\frac{\partial \pi}{\partial q_3} = 0$$

$$\frac{\partial \pi}{\partial q_4} = 0$$

$$\begin{bmatrix} k_1 + k_2 & -k_2 & 0 \\ -k_2 & k_2 + k_3 & -k_3 \\ 0 & -k_3 & k_3 \end{bmatrix}$$

-5

$$q_2 = 0.02 \times 10^{-5}$$

$$q_3 = 0.06 \times 10^{-5}$$

$$q_4 = 0.10 \times 10^{-5}$$

[1.0]



SECOND SEMESTER 2012- 2013

ME C382 Computer aided design

Time: 50min

1. Answer all questions
2. Class notes & Text book are permitted
3. Assume suitable data, if required

Test 2

Marks: 30

Date: 8.5.13

Weightage: 15%

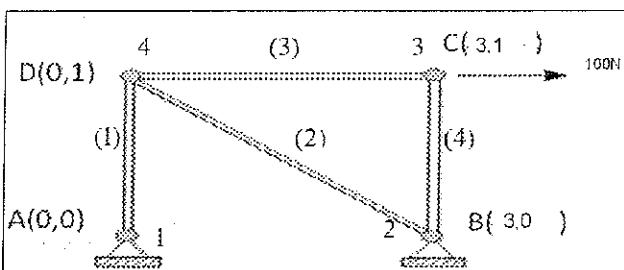


Fig. 1

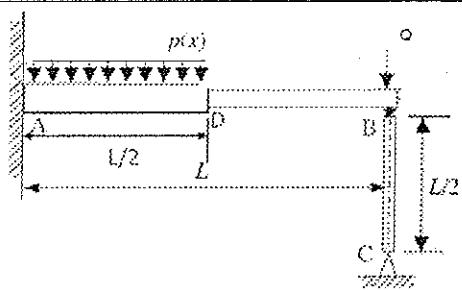


Fig. 2

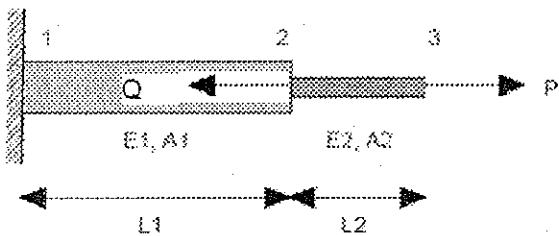


Fig. 3

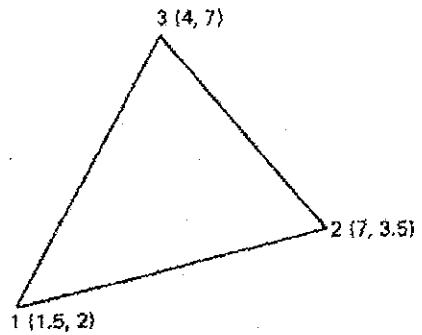


Fig. 4

Q1. Determine the final structural equation for the structure given in Fig.1. The dimensions are in metres. $E=200\text{GPa}$ and $A = 0.0005 \text{m}^2$. [7]

Q2. Determine the final structural equation for the structure in Fig.2. $p(x) = 1\text{kN/m}$; $Q=2\text{kN}$; I_{AD} (Moment of inertia) $=0.0004\text{m}^4$; $I_{DB}=0.0001\text{m}^4$; $I_{BC} = 0.00005\text{m}^4$ & $L=4\text{m}$. [7]

Q3. The data related to the structural member shown in Fig.3 is given as follows: $E_1 = 150 \text{ GPa}$; $A_1=0.005\text{m}^2$; $L_1=2\text{m}$; $Q=500\text{N}$; $E_2=150\text{GPa}$; $A_2=0.002 \text{ m}^2$; $L=0.5\text{m}$ and $P= 200\text{N}$. Using potential energy minimization method, determine the displacement at the free end. [8]

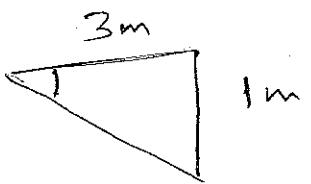
Q4. Establish the strain-displacement relation matrix for the 2D element in Fig.4. If an infinite length bar is made using the cross section given in the fig.4 with transverse load, determine the stress – strain relationship matrix. $E = 200\text{GPa}$ & Poisson's ratio = 0.35. [8]

8/5/13

MEC 382 Computer Aided Design

Test 2 Solutions

A-1 Elements 1, 2, 4
are truss elements



Element 3 is bar

Element

$$\tan \theta = \frac{1}{3}$$

$$\theta = -19^\circ$$

For truss elements:

$$k^e = \frac{AE}{L} \begin{bmatrix} c^2 & cs & -c^2 & -cs \\ cs & s^2 & -cs & -s^2 \\ -c^2 & -cs & c^2 & cs \\ -cs & -s^2 & cs & s^2 \end{bmatrix}$$

$$c = \cos \theta$$

$$s = \sin \theta$$

Or bar element

$$k^e = \frac{AE}{L} \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$$

From the structural equation

$$[k_g] [u] = [f]$$

and apply the boundary condition

[7]

~~A.2~~

The Structure can be divided into
2 beam elements and 1 bar element.

For beam elements

$$K^e = \frac{EI}{L^3} \begin{bmatrix} 12 & 6L & -12 & 6L \\ 6L & 4L^2 & -6L & 2L^2 \\ -12 & -6L & 12 & -6L \\ 6L & 2L^2 & -6L & 4L^2 \end{bmatrix} \begin{bmatrix} \theta_1 \\ \theta_1 \\ \theta_2 \\ \theta_2 \end{bmatrix}$$

for bar elements

$$K^e = \frac{AE}{L} \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$$

For distributed load $f =$

$$\begin{bmatrix} PL/2 \\ PL^2/12 \\ PL/L \\ -PL^2/12 \end{bmatrix} \begin{bmatrix} \theta_1 \\ \theta_1 \\ \theta_2 \\ \theta_2 \end{bmatrix}$$

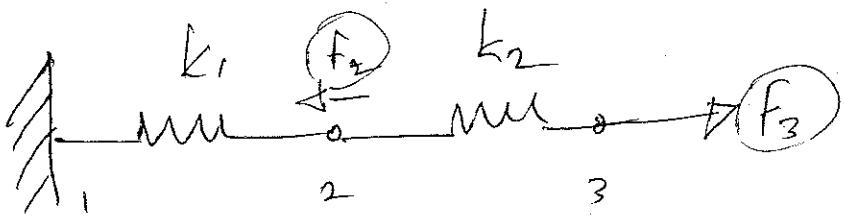
Determine the Structural eqn.

$$[k_g] [Eu] = [f]$$

and apply boundary condition

[7]

A-3



$$k_1 = \frac{A_1 E_1}{L_1} \quad , \quad k_2 = \frac{A_2 E_2}{L_2}$$

$$\bar{\tau} = \frac{1}{2} [k_1 \delta_1^2 + k_2 \delta_2^2] - F_3 q_3 \\ + F_2 q_2$$

$$\delta_1 = -q_2, \quad \delta_2 = (q_2 + q_3)$$

Sub. δ_1 & δ_2 in terms (q_1, q_2, q_3)

Apply $\frac{\partial \bar{\tau}}{\partial q_1} = 0; \quad \frac{\partial \bar{\tau}}{\partial q_2} = 0; \quad \frac{\partial \bar{\tau}}{\partial q_3} = 0$

Solve for $q_2 + q_3$. (Since $q_1 = 0$)

[8]

~~A-4~~
Strain-displacement matrix = [B]

$$B = \frac{1}{2A} \begin{bmatrix} \beta_i & 0 & \beta_j & 0 & \beta_m & 0 \\ 0 & \gamma_i & 0 & \gamma_j & 0 & \gamma_m \\ \gamma_i & \beta_i & \gamma_j & \beta_j & \gamma_m & \beta_m \end{bmatrix}$$

$$\beta_i = y_j - y_m$$

$$\gamma_i = x_m - x_j$$

$$\beta_j = y_m - y_i$$

$$\gamma_j = x_j - x_m$$

$$\beta_m = y_i - y_j$$

$$\gamma_m = x_j - x_i$$

($i = \text{node 1}$; $j = \text{node 2}$; $m = \text{node 3}$) [5]

$A = \text{area of the triangular element}$

$$2A = x_i(y_j - y_m) + x_j(y_m - y_i) + x_m(y_i - y_j)$$

Use plane stress condition for infinite length bar

$$D = \begin{bmatrix} 1-r & 0 & 0 \\ r & 1-r & 0 \\ 0 & 0 & 0.5-r \end{bmatrix} \times \frac{E}{(1+r)(1+2r)}$$

X —

[3]



SECOND SEMESTER 2012- 2013

ME C382 Computer aided design

Time: 50min

Test 1

Marks: 30

Date: 20.3.13

Weightage: 15%

Answer all questions (6x5=30Marks)

Assume suitable data, if required

Q1. Construct the CSG tree for Fig. 1.

Q2. Check the validity of the solid model shown in Fig.2.

Q3. Fig.3 has the vertices $(0,0,0)$, $(2,0,0)$, $(2,3,0)$, $(0,3,0)$, $(1,1,1)$ & $(1,2,1)$. Determine the locations of front view, top view and right side view using orthographic projection. Show the views by rough sketches.

Q4. For Fig.4, do the following operations and show rough sketches after each operation.

(i) $A \cup B$ (ii) $A \cap B$ (iii) $A \Delta B$ (iv) $A \cap B$

Q5. Determine the hierarchy data structure for Fig.5. (pin over a block).

Q6. Consider a triangle with the following vertices: A (1,3,4), B(4,3,4) and C(3,6,4). The triangle is rotated ccw 45° about Y axis. When the triangle is projected from Z=9, determine the position of triangle on the viewing plane.

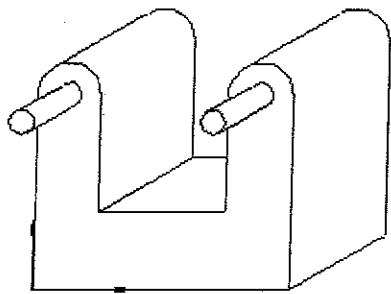


Fig.1 (Q1)

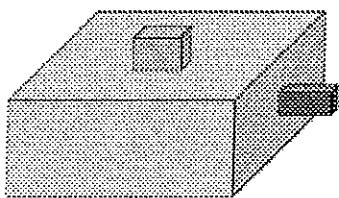


Fig.2(Q2)

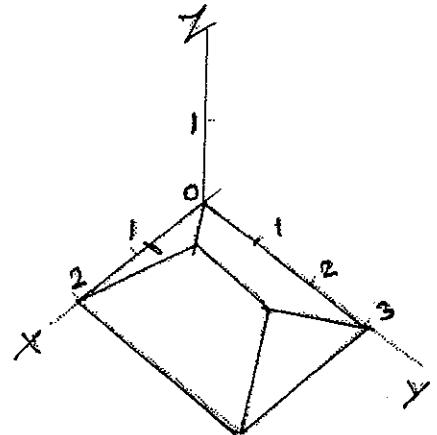


Fig.3 (Q3)

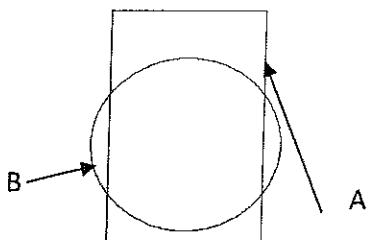


Fig.4 (Q4)

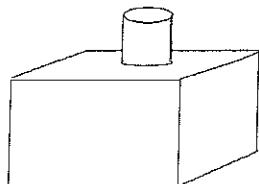
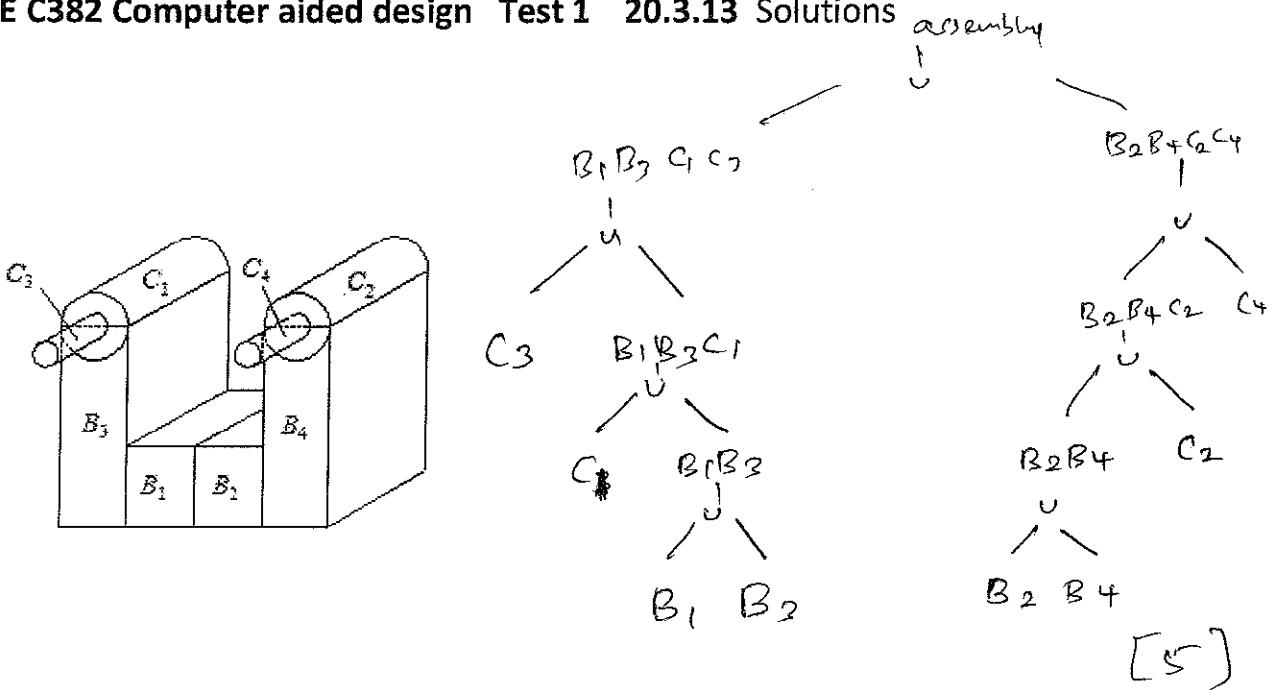


Fig.5 (Q5)



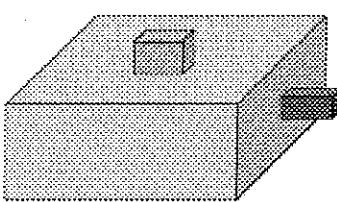
ME C382 Computer aided design Test 1 20.3.13 Solutions



[5]

Validity Checking for Polyhedra with inner loops

$$F - E + V - L = 2(B - G) \quad \text{General}$$



$$E = 36$$

$$F = 16$$

$$V = 24$$

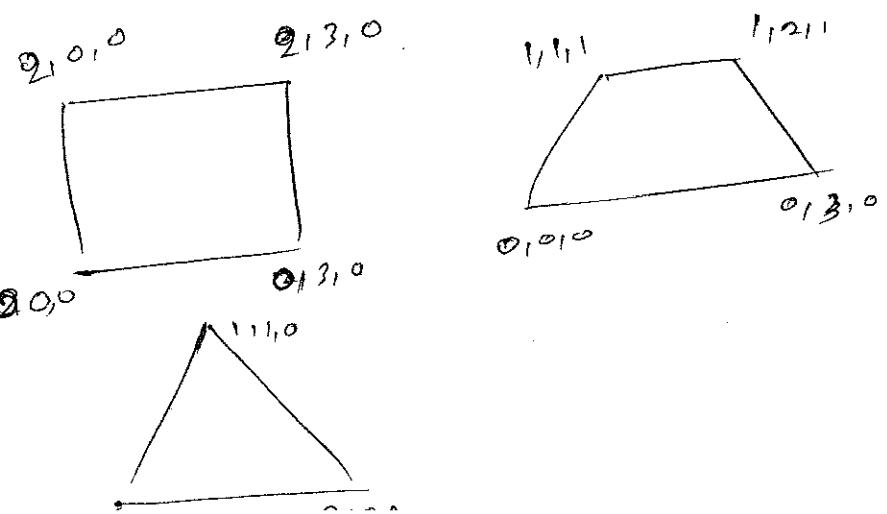
$$L = 2$$

$$B = 1$$

$$G = 0$$

$$16 - 36 + 24 - 2 = 2(1 - 0) = 2$$

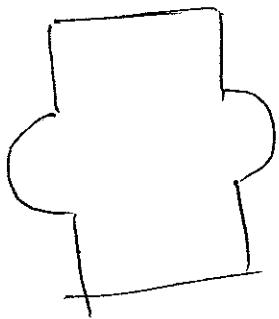
[5-]



[5]

(2)

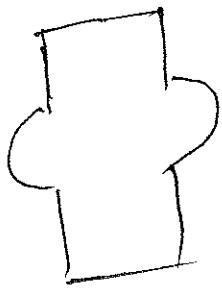
A-B



A ∪ B



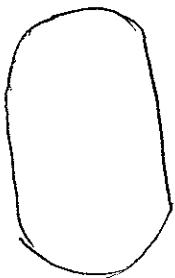
i(A ∪ B)



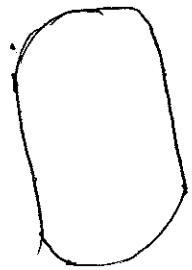
$$ki(A \cup B) = A \cup^* B$$

[5]

A ∩ B



i(A ∩ B)

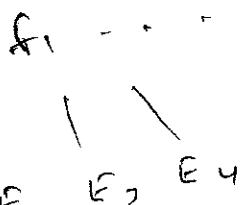


$$ki(A \cap B) = A \cap^* B$$

block/pri

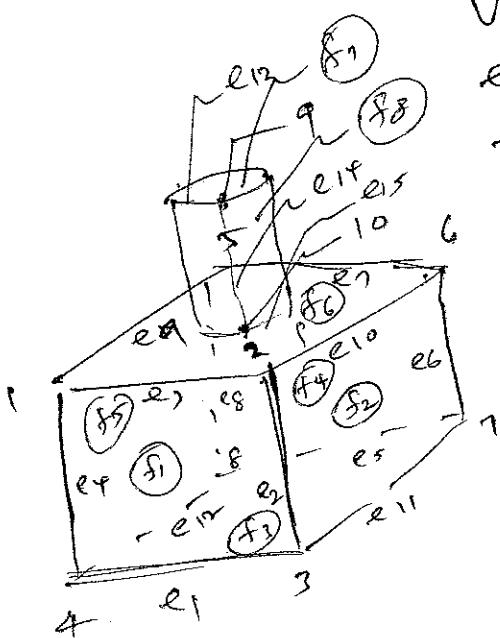
Block
pri

pri
f, f₈

f₈

[5]

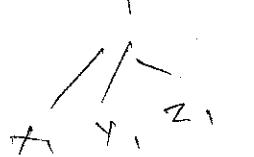
A-S



$$V = 10$$

$$E = 15$$

$$F = 8$$



(3)

A →

$$\begin{bmatrix} 1 & 3 & 4 & 1 \\ 4 & 7 & 4 & 1 \\ 3 & 6 & 4 & 1 \end{bmatrix}$$

$$\times \begin{bmatrix} \cos 45 & 0 - \sin 45 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \sin 45 & 0 & \cos 45 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\times \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & -\sqrt{3}/2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\times \begin{bmatrix} 3.563 & 3 & 0 & 0.7463 \\ 5.6569 & 3 & 0 & 1 \\ 4.949 & 6 & 0 & 0.924 \end{bmatrix}$$

$$\times \begin{bmatrix} 4.77 & 4.02 \\ 5.66 & 7.00 \\ 5.35 & 6.51 \end{bmatrix}$$

[5]

— X —



SECOND SEMESTER 2012- 2013

Name:

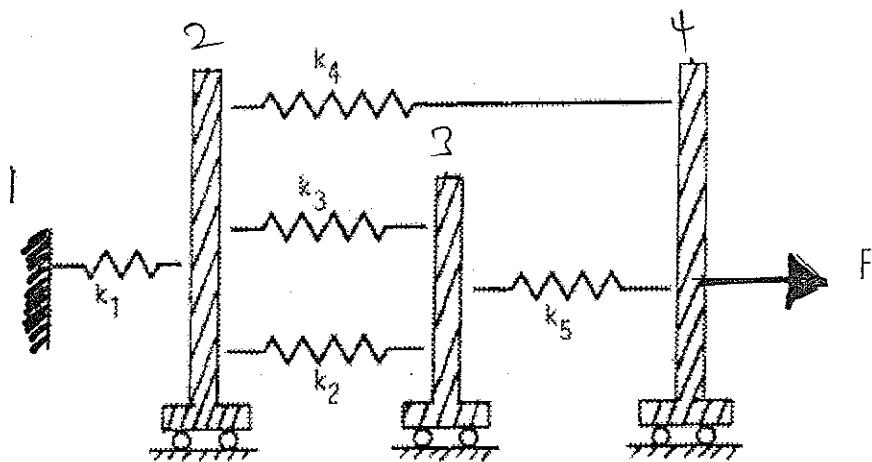
ID No.

Date: 17.4.13

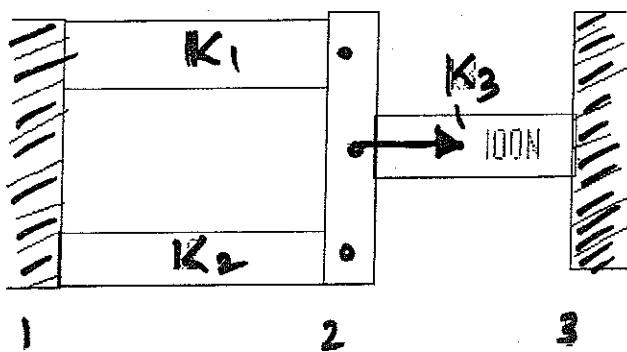
ME C382 Computer aided design Quiz 2 Time: 20min Marks: 10 Weightage: 5%

Answer all questions

1. Determine the assembly of element stiffness matrices and apply boundary conditions. Show the resultant structural global structural equation in matrix form.[4]



2. Area of each bar in the structure = 0.01m^2 . $L_1=L_2=2\text{m}$ and $L_3=1\text{m}$; $E = 200\text{GPa}$. Determine the nodal displacements and elemental strains for the structure given below. [3+3]



Stiffness Matrix

$$K_e^1 = \begin{bmatrix} k_1 & -k_1 \\ -k_1 & k_1 \end{bmatrix}$$

$$K_e^2 = \begin{bmatrix} k_2 & -k_2 \\ -k_2 & k_2 \end{bmatrix}$$

$$K_e^3 = \begin{bmatrix} k_3 & -k_3 \\ -k_3 & k_3 \end{bmatrix}$$

$$K_e^4 = \begin{bmatrix} k_4 & -k_4 \\ -k_4 & k_4 \end{bmatrix}$$

$$K_e^5 = \begin{bmatrix} k_5 & -k_5 \\ -k_5 & k_5 \end{bmatrix}$$

Assembly

$$K_g = \begin{bmatrix} k_1 & -k_1 & 0 & 0 \\ -k_1 & k_1 + k_2 + k_3 + k_4 & -k_2 - k_3 & -k_4 \\ 0 & -k_2 - k_3 & k_2 + k_3 + k_5 & -k_5 \\ 0 & -k_4 & -k_5 & k_4 + k_5 \end{bmatrix} \quad \begin{bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 0 \\ 0 \\ F \end{bmatrix}$$

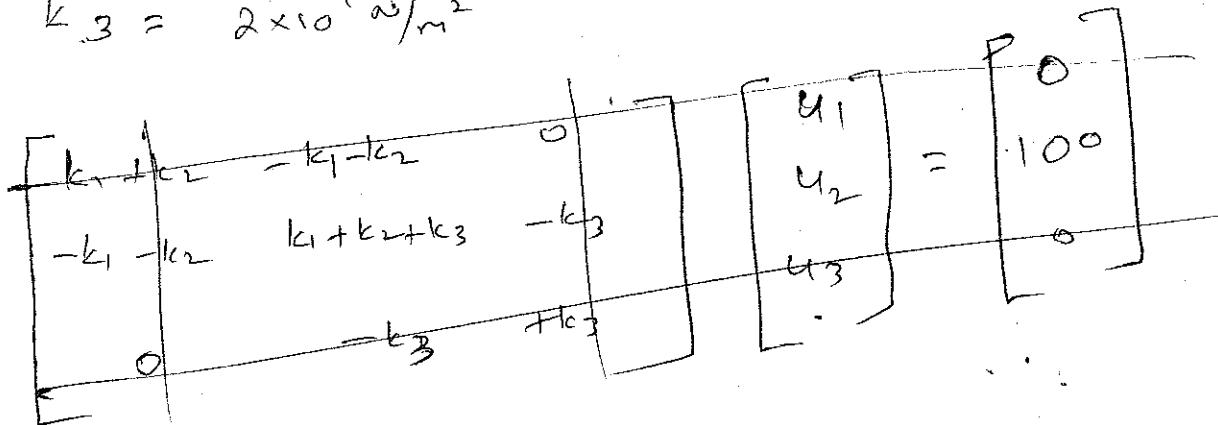
Structural Eqn

$$\begin{bmatrix} k_1 + k_2 + k_3 + k_4 & -k_2 - k_3 & -k_4 \\ -k_2 - k_3 & k_1 + k_2 + k_5 & -k_5 \\ -k_4 & -k_5 & k_4 + k_5 \end{bmatrix} \quad \begin{bmatrix} u_2 \\ u_3 \\ u_4 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 0 \\ F \end{bmatrix}$$

[4]

$$k_1 = k_2 = \frac{AE}{L_1} = 1 \times 10^9 \text{ N/m}^2$$

$$k_3 = 2 \times 10^8 \text{ N/m}^2$$



$$k_1 + k_2 + k_3 = u_2 \times 100 \quad [3]$$

$$u_2 = 2.5 \times 10^{-8} \text{ m}$$

$$u_1 = u_3 = 0$$

$$\epsilon_1 = \frac{u_2 - u_1}{l} = \underline{\underline{1.25 \times 10^{-8} \text{ m}}}$$

$$\epsilon_2 = \frac{u_2 - u_1}{l} = \underline{\underline{1.25 \times 10^{-8} \text{ m}}}$$

$$\epsilon_3 = \frac{u_3 - u_2}{l} = \underline{\underline{-2.5 \times 10^{-8} \text{ m}}}$$

[3].

X



SECOND SEMESTER 2012- 2013

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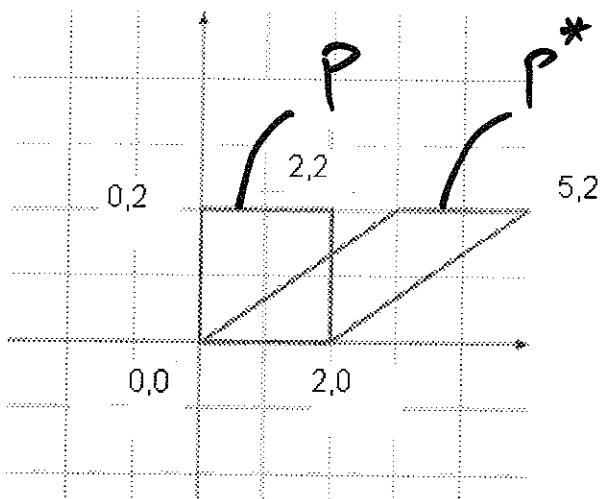
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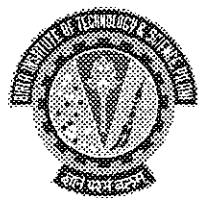
Date: 27.2.13

ME C382 Computer aided design Quiz 1 Time: 20min Marks: 10 Weightage: 5%

Answer all questions

1. Determine the matrix transformation that will transform the coordinates of the rectangle A(10,10), B(50, 10), C(50, 30) and D(10, 30), into the coordinates of a square with sides of 60 units about the centroid of the rectangle. Also, determine the final position matrix. [5]
2. Determine the final position of a vertex (2,3) after reflection about $y=x$ axis. [3]
3. Determine the transformation matrix for the transformation shown below. [2]





Solutions

A1.

$$\text{Centroid} = (30, 20)$$

$$P^* = P \times T(-t) \times T(\text{scaling}) \times T(+t)$$

$$T_{\text{scaling}} = [1.5000 \quad 0 \quad 0 \quad 0]$$

$$0 \quad 2.0000 \quad 0 \quad 0$$

$$0 \quad 0 \quad 1.0000 \quad 0$$

$$0 \quad 0 \quad 0 \quad 1.0000]$$

$$P^* = [0 \quad -10 \quad 0 \quad 1$$

$$60 \quad -10 \quad 0 \quad 1$$

$$60 \quad 50 \quad 0 \quad 1$$

$$0 \quad 50 \quad 0 \quad 1];$$

A2.

$$p = [2 \quad 3 \quad 0 \quad 1];$$

$$P^* = p \times T-45 \times T_{\text{ref}} \times T+45$$

$$P^* = [3 \quad 2 \quad 0 \quad 1];$$

A3.

X Shear factor = 1.5;

$$T_{\text{shear}} = [1.0000 \quad 0 \quad 0 \quad 0$$

$$1.5000 \quad 1.0000 \quad 0 \quad 0$$

$$0 \quad 0 \quad 1.0000 \quad 0$$

$$0 \quad 0 \quad 0 \quad 1.0000];$$

