KINETO-ELASTODYNAMIC ANALYSIS OF A FOUR-BAR

AND ITS COGNATE MECHANISM

By

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CHAPTER I

INTRODUCTION

A detailed survey of the existing literature in the field of kinematic reveals the fact that the rigidity assumption in the design of mechanisms which are composed of links, gears, sliders, etc., fails to supply the need of accuracy in the output function of a mechanism wherever high speed is a criterion for fast production.

The simplest and most useful mechanism is a four-bar linkage, the application of which is extensive such as in a printing machine or a gripping device for speed packaging or labelling, etc. At a high operating speed, the mechanism designed on the basis of rigidity may fail to accomplish the goal because of the inertial and external forces inducing elastic deflections in the links.

Kineto-elasto dynamics (K.E.D.) is the study of mechanisms in motion consisting of deformable elastic elements which may deflect due to external loads or internal body forces.

Several authors have dealt with "elastic-complex system," i.e., the mixed elastic and non-elastic members (1)(2). Because of the complexity in obtaining the solution, usually one element in the mechanism members is treated as elastic, thereby treating only one degree of elastic freedom in deformation, i.e., torsion, extension, or flexure alone. The most adequate technique often employed is the Lagrangian-Mechanics to derive equations of motion, but unfortunately, the

assumptions for simplifying sacrifice the reality of the problem.

Burns and Crossley (3) performed a kineto-elasto static synthesis on a four-bar function generator with a flexible coupler. Kohli, Hunter, and Sandor (4) presented elasto dynamic analysis of a slidercrank mechanism using Euler-Lagrange Differential Equations of motion, which is an extension of the Lagrangian Mechanics mentioned above.

Notable contribution is made by Erdman (5), who presented for the first time the KEDSRO (Kineto-Elastodynamic-Stretch Rotation Operator) for the synthesis of a completely elastic model. Synthesis of planar four-bar Crank Rocker mechanism with elastic links using Stiffness-Approach is investigated by Patwardhan and Soni (6).

The above cited literature survey reveals that the designers have treated the effect of elasticity in linkages by simply over-designing the mechanism with a few exceptions of synthesis considering elasticity in the mechanism members (4)(6). No further attention was focussed on analyzing the cognate mechanisms which are an alternate answer to a source mechanism. The search for accurate synthesis procedures whereever high speed and accuracy is the objective requires first a complete and accurate K.E.D. analysis of the mechanism where all of the links are considered to be elastic.

This thesis presents a generalized approach where four-bar path generating source and coupler-cognate mechanisms are analyzed with all of their links regarded as elastic, and are examined based on the flexibility method of structural analysis. The mechanism is frozen in various configurations and analyzed as an instantaneous structure (with elastic members) to determine the elastic displacements of its path generating coupler point. Since the cognate mechanism can be a

substitute for the source mechanism whose coupler point generates the same curve in rigid mode, analysis is done for one of its cognate mechanisms.

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The procedure involves the following three cases in increasing level of accuracy for both source and its cognate mechanism.

 Completely elastic moving system where the links are assumed to be mass-less compared to an inertial mass located at the path point.

 Each element having a concentrated or disc mass located at each joint.

3) Mass of each element is distributed along the element in the form of sub-elements.

A brief discussion about the coupler cognate mehcanisms of a fourbar is presented in Chapter II. The structural analysis based on flexibility approach is applied to mechanisms in Chapter III. The necessary equations for computing the K.E.D. deflections for the source and its cognate mechanisms are developed for the three above mentioned cases in Chapter IV. The results and conclusions are presented in Chapter V.

CHAPTER II

FOUR-BAR COGNATE MECHANISMS

Alternate mechanisms that differ in dimensions but have the same kinematic performance are called cognate mechanisms. If the three fourbars as shown in Figure 1a are examined, all three produce the same coupler curve generated by a common coupler point of the coupler. The fourbars (not being identical) are called Robert's cognate mechanisms or cognate to each other (8). These cognate mechanisms are built using the construction of parallelograms and similar triangles. They have a common frame as well as a common coupler point. Figure 1a demonstrates the construction of the cognates as follows:

 The source mechanism with the coupler point "P" is constructed to a suitable scale as MAPBQ.

2) The parallelograms BQEP and AME'P are constructed on either side of the source four-bar linkage.

3) PED and E'PD' are similar triangles both similar to the coupler triangle PBA.

4) The construction of the parallelogram PDOD' locates "O" the other fixed point for the cognates.

A close consideration reveals that the two cognates, namely, ODEQ and OD'E'M, are obtained by geometric stretch rotation. The operation of Stretch-Rotation is a spiral similarity transformation, which is a combination of central dilatation and rotation about the centers Q and



Figure 1a. Cognate Mechanisms of a Source Four-Bar Linkage

PE = BQ MA = E'P PA = E'M EQ = PB

Triangles PAB, DPE, AND D'E'P are similar triangles

 $\begin{array}{rrrr} \mbox{Angle OMQ} &= & \alpha \\ \mbox{Angle OQM} &= & \beta \\ \mbox{Angle MOQ} &= & \gamma \end{array}$



Figure 1c. Left Side Cognate (showing the link MQ rotated about M and stretched by a factor $K = \frac{OM}{MQ}$)

M for the two cognates ODEQ and OD'E'M, respectively. The new link lengths are a multiple of the dilatation factor, K, and the arguement is the rotation of the fixed link MQ to QO (about the point Q) through a fixed angle β (as shown in Figure 1b) for the right side cognate ODEQ. For the left side cognate, the fixed link MQ of the source mechanism has rotated through an angle α about the point M and stretched by a factor K (as shown in Figure 1c).

Since both the dilatation factor K and the arguements MQO and QMO are independent of time for a rigid transformation, the input angular displacements of the links do not change. Further, the link OD makes the same input angle with the fixed link OQ as the source mechanism link MA makes with its fixed link MQ. Since the angular displacements for the input links of the source and its cognates do not change, the input velocity for all of the input links remains the same.

A quick way to find the link-lengths of the coupler-cognate mechanisms is the usage of Caley's diagram, as shown in Figure 2. Caley's diagram is obtained by making the coupler links AB, DE, E'D' coincide with the fixed links MQ, QO, MO of the three four-bars as shown in Figure 1a. Using the properties of the similar coupler triangles PAB, DPE, D'E'P, the link lengths of the cognate mechanisms are obtained.

To determine the deflections of the coupler point of both the source and its cognate mechanism, considering all links to be elastic, a Crank-Rocker mechanism is selected as a source linkage which has a cognate of crossed configuration. However, the methodology developed is for any four-bar linkage. K.E.D. analysis for both the source and its cognate is performed by the method of Structural analysis using the flexibility approach discussed in the next chapter.

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CHAPTER III

STRUCTURAL ANALYSIS APPROACH APPLIED TO

MECHANISMS

This section of the thesis demonstrates how the method of structural analysis may be applied to the analysis of mechanisms in motion. A structure can be changed into a mechanism by removing one or more physical constraints of the structure thus allowing rigid body motion of its members. For example, a rectangular pinned frame within a diagonal bar may be transformed from a structure of rigid body components having zero degree of freedom into a mechanism with a degree of freedom of one by the removal of the diagonal bar as shown in Figures 3a, 3b.

The above transformation is reversible. A mechanism can be reduced to a structure by adding physical constraints; that is, by reducing its degrees of freedom to at least zero.

This thesis is based partially on the representation of a mechanism as a statically "Instantaneous Structure" by adding one or more mobile constraints. For example, the configuration of a four-link mechanism is determined at a particular angle of the input-link. Once this angle is set, the whole mechanism can be frozen for that instant as a structure.

For a particular set of the input angle of the four link mechanism, the input-link (Element 1) is modelled as a cantelever-beam or free-fixed beam (as shown in Figure 4a). For this cantelever beam of









Four-Bar Mechanism Figure 4.

MA - input-link of length - L1 AB - coupler link of length = L3 AP - coupler extender of length L2 making a rigid angle 'α' with AB BQ - follower link of length L4 MQ - Fixed or grounded link of length L5



Figure 4a. Input Element as a Cantilever Beam



Figure 4b. Coupler Link Modelled as Simply Supported Beam With End Moments





length L1, the cross-sectional area A, Modulus of elasticity E, crosssectional moment of inertia I (about an axis-Z normal to the plane of the mechanism), the internal element forces f_1 , f_2 , and the internal element moment f_3 cause corresponding translations d_1 , d_2 , and angular deflection d_3 at the end of the element.

These forces and displacements can be expressed as follows:

$$\begin{bmatrix} d_1 \\ d_2 \\ d_3 \end{bmatrix} = \begin{bmatrix} F \end{bmatrix} \begin{bmatrix} f_1 \\ f_2 \\ f_3 \end{bmatrix}$$

(1)

where F is the element flexibility matrix given as

$$\begin{bmatrix} F \end{bmatrix} = \begin{bmatrix} L_{1}/AE & 0 & 0 \\ 0 & L_{1}^{3}/3EI & L_{1}^{2}/2EI \\ 0 & L_{1}^{2}/2EI & L_{1}/EI \end{bmatrix}$$
(2)

The out-put link of the four-bar linkage (Element 4) is a two force member. A two force member with two pin joints can transmit only longitudinal force as shown in Figure 4c. Thus, the link 4 has one elastic degree of freedom (extensibility) and its element flexibility matrix has only one term

$$\begin{bmatrix} F \end{bmatrix} = \begin{bmatrix} L_4 / AE \end{bmatrix}$$

and the element deflection is given as

$$\begin{bmatrix} d_1 \end{bmatrix} = \begin{bmatrix} L_4 / AE \end{bmatrix} \begin{bmatrix} f_1 \end{bmatrix}$$
(4)

for some cases where a mechanism link is not just a simple straight beam, for example, in the four-bar linkage of Figure 4 the coupler link is composed of two elements rigidly fixed at an angle α , the extender element 2 may be treated as a simple cantelever beam with three elastic degrees of freedom while element 3 behaves like a simply supported beam with a moment on the left end due to element 2 and a longitudinal force as shown in Figure 4b.

The element flexibility matrix for the element 3 is

(3)



The above method of modelling the elastic motion of a mechanism is not limited to only a four-bar mechanism but can be extended to a multilink mechanism. Gears teeth are investigated by considering the tooth as a cantilever beam (9). The total deformation of the tooth can be calculated which is a result of direct compression at the point of contact between teeth, beam deflection, and shear. This theory can also be extended to spatial-linkages considering proper degrees of freedom and the forces induced in the mechanism members.

CHAPTER IV

ELASTO-DYNAMIC DEFLECTION ANALYSIS APPROACH

The flexibility approach of structural analysis to the individual element was demonstrated in the previous section. This section deals with the total setup of the whole mechanism under consideration.

Considering that the mechanism has several external "system forces" or generalized forces acting on it (including inertia moments and forces), a deflected configuration of the instantaneous structure is desired.

The flexibility approach permits in determining the deformations in the direction of any desired set of system coordinates. If the system forces are represented by a column matrix P_j , j = 1, ..., n where n is the number of system forces and system coordinates. Since the number of elastic degrees of freedom of the mechanism system is the sum of the independent internal forces of its elements, every independent internal force has a corresponding element coordinate X_j , i = 1, ..., m, where m is the number of element coordinates.

The system forces may be transormed into element or internal forces f_i , $i = 1, \ldots m$ each acting in the respective element coordinate direction by deriving an (mXn) force transformation matrix by the method of rigid member static analysis (7).

The matrix described above is dependent on the configuration of the system. It is thus a function of the reference variables of the

mechanism. Since a four-bar mechanism has only one reference variable, namely the input angle, the force transformation matrix is a function of the input angle.

The flexibility matrices of the elements can be assembled to form an element flexibility matrix for the whole system. This is derived in a later section. The element flexibility matrix is independent of the configuration of the mechanism position.

The element deformation matrix is thus the product of the element flexibility matrix with the force transfer matrix and the element force matrix, as

$$\mathbf{d} = \begin{bmatrix} F \end{bmatrix} \begin{bmatrix} f \end{bmatrix} = \begin{bmatrix} F \end{bmatrix} \begin{bmatrix} \beta \end{bmatrix} \begin{bmatrix} P \end{bmatrix}$$

where $\begin{bmatrix} \beta \end{bmatrix} \begin{bmatrix} P \end{bmatrix}$ gives the forces acting on the mechanism in a particular configuration.

These element deformations will have a resulting effect for the whole system of the mechanism. Thus, these element deflections are transferred to system deflections by pre-multiplying these element deflection matrices by the transposed force transfer matrix. The conversion of element deflections to system deflections is described in reference (7).

The system deflections are given as:

$$\left[\begin{array}{c} \delta \\ \end{array}\right] = \left[\begin{array}{c} \beta \\ \end{array}\right]^{\mathsf{t}} \left[\begin{array}{c} F \\ \end{array}\right] \left[\begin{array}{c} \beta \\ \end{array}\right] \left[\begin{array}{c} \beta \\ \end{array}\right] \left[\begin{array}{c} P \\ \end{array}\right]$$

where the element force vector is

 $\begin{bmatrix} f \end{bmatrix} = \begin{bmatrix} \beta \end{bmatrix} \begin{bmatrix} P \end{bmatrix}$

and the element deflection vector is $\begin{bmatrix} d \end{bmatrix} = \begin{bmatrix} F \end{bmatrix} \begin{bmatrix} f \end{bmatrix}$

.(7)

(6)

The flexibility approach described above is demonstrated on a planar four-bar and its cognate mechanism to determine the displacements (elastic) of the path point through its cycle of motion.

K.E.D. Assumptions

The following assumptions are made:

1) All deformations are in the elastic range.

2) Joints between the links are non-elastic, have no play, they are mass-less and frictionless compared to the rest of the mechanism.

3) The input angular-velocity of the input-link is constant.

4) The coupler link has an extender which makes a rigid angle α with the coupler link of the source four-bar and a rigid angle γ with the coupler link of its cognate. The four links, i.e., the input link, extender, coupler link, and the follower link are assumed to be flexible in the plane of motion and extensible. The same assumption applies for its cognate.

5) Since the path-point deviation of both source and cognate mechanisms is under consideration, each mechanism has three system coordinates. This system is an ortho-normal translating coordinate system in which X and Y coo-dinate systems remain parallel to an inertial system and are located in the plane of motion and Z coordinate expresses the angular orientation located at the pathpoint.

6) The mechanism motion is considered to be in the horizontal plane; thereby effect of gravity is eliminated.

Three cases are considered in an increasing level of accuracy:

Case I: Completely elastic moving system where the links are assumed mass-less compared to an inertial mass at the path-point.

Case II: Each element has a concentrated or a disc mass located at each joint.

Case III: Mass of each element is distributed along the element in the form of sub elements.

Case I: Lumped Mass at Path Point

K.E.D. Analysis is performed for the source and its cognate mechanism where links are considered to be mass-less compared to an inertial mass at the coupler point. Equation (6) derived above is used to determine the elastic displacement of the coupler point shown in Figure 5. The deflections are given as

$\left[\delta \right] = \left[\beta \right]^{\mathsf{t}} \left[F \right] \left[\beta \right] \left[P \right]$

The force transformation matrix $\begin{bmatrix} \beta \end{bmatrix}$, the element flexibility matrix $\begin{bmatrix} F \end{bmatrix}$, and the system force matrix $\begin{bmatrix} P \end{bmatrix}$ are calculated for this case.

Derivation of the Force Transformation Matrix for Case I. The force transformation matrix for the source four link mechanism (Figure 5) is derived in this section as follows (referring to Figure 6b):

$$f_{1} = P_{1}\cos(\Theta_{3}+\alpha) + P_{2}\sin(\Theta_{3}+\alpha)$$

$$f_{2} = -P_{1}\sin(\Theta_{3}+\alpha) + P_{2}\cos(\Theta_{3}+\alpha)$$

$$f_{3} = P_{3}$$
(9)

Referring to Figure 6 for the coupler and the extender, the sum of



Figure 5. Source Four Bar Showing System Forces P_1, P_2, P_3





(a)

the horizontal forces on the coupler is:

$$P_1 - f_4 \cos(\Theta_2) + f_5 \sin(\Theta_2) - f_6 \cos(\Theta_4) = 0$$

i.e.,

$$P_1 = f_4 \cos(\Theta_2) - f_5 \sin(\Theta_2) + f_6 \cos(\Theta_4)$$
(10)

The sum of the vertical forces on the coupler is:

$$P_2 = f_4 \sin(\Theta_2) + f_5 \cos(\Theta_2) + f_6 \sin(\Theta_4)$$
(11)

The moments about the coupler point P are

$$P_{3} = \left\{ L_{2} \cos(\Theta_{3} + \alpha) (-\sin(\Theta_{2})) + L_{2} \sin(\Theta_{3} + \alpha) \cos(\Theta_{2}) \right\} f_{4}$$

$$+ \left\{ L_{2} \cos(\Theta_{3} + \alpha) (-\cos(\Theta_{2})) - L_{2} \sin(\Theta_{3} + \alpha) \sin(\Theta_{2}) \right\} f_{5}$$

$$+ \left\{ (L_{3} \cos(\Theta_{3}) - L_{2} \cos(\Theta_{3} + \alpha)) (\sin(\Theta_{4})) \right\}$$

$$+ \left(L_{2} \sin(\Theta_{3} + \alpha) - L_{3} \sin(\Theta_{3})) (\cos(\Theta_{4})) \right\} f_{6} \qquad (12)$$

Equations (10), (11), and (12) are of the form:

$$P_{1} = af_{4}+bf_{5}+cf_{6}$$

$$P_{2} = df_{4}+ef_{5}+ff_{6}$$

$$P_{3} = gf_{4}+hf_{5}+if_{6}$$
(13)

Solution of equation (13) by Cramer's rule yields:

$$f_{4} = \frac{(ei-fh)P_{1}+(ch-bi)P_{2}+bf-ce)P_{3}}{r}$$

$$f_{5} = \frac{(fg-di)P_{1}+(ai-cg)P_{2}+(cd-af)P_{3}}{r}$$
(14)
$$f_{6} = \frac{(dh-eg)P_{1}+(bg-ah)P_{2}+(ae-bd)P_{3}}{r}$$

where

$$r = a(ei-fh)-b(di-fg)+c(dh-eg)$$

The free body diagram for the element 3 as shown in Figure 7 helps in determining the element forces f_7 and f_8 .

$$f_{7} = -f_{6} \cos(\Theta_{4} - \Theta_{3})$$

$$f_{9} = L_{3} f_{6} \sin(\Theta_{4} - \Theta_{3})$$
(15)

Referring to Figure 8, for both coupler and extender summing moments about the point A, f_6 can be expressed in terms of the system forces P_1 , P_2 , P_3 , as follows:

$$f_6 = \frac{-L_2 \sin(\Theta_3 + \alpha) P_1 + L_2 \cos(\Theta_3 + \alpha) P_2 + P_3}{L_3 \sin(\Theta_4 - \Theta_3)}$$

Thus



Figure 7. Free Body Diagram for Element 3





Figure 8. Force Diagram for Coupler and Coupler Extender

$$f_{7}=(L_{2}/L_{3})\cot(\Theta_{4}-\Theta_{3})\sin(\Theta_{3}+\alpha)P_{1}-(L_{2}/L_{3})\cot(\Theta_{4}-\Theta_{3})\cos(\Theta_{3}+\alpha)P_{2}$$
$$-\cot(\Theta_{4}-\Theta_{3})(1/L_{3})$$
(16)

and

$$f_8 = -L_2 \sin(\Theta_3 + \alpha) P_1 + L_2 \cos(\Theta_3 + \alpha) P_2 + P_3$$

Combining equations (9), (14), (16), and expressing in a matrix form, the element forces f_1 , f_2 ,..., f_8 are obtained from the system forces P_2 , P_2 , P_3 .

The following symbols are used for space limitation:

$$S\alpha \Theta_{3} = \sin(\Theta_{3} + \alpha)$$

$$C\alpha \Theta_{3} = \cos(\Theta_{3} + \alpha)$$

$$T\Theta_{4}\Theta_{3} = \cot(\Theta_{4} - \Theta_{3})$$

$$S\Theta_{2} = \sin(\Theta_{2})$$

$$C\Theta_{2} = \cos(\Theta_{2})$$

$$S\Theta_{3} = \sin(\Theta_{3})$$

$$C\Theta_{3} = \cos(\Theta_{3})$$

$$S\Theta_{4} = \sin(\Theta_{4})$$

$$C\Theta_{4} = \cos(\Theta_{4})$$



$$\begin{bmatrix} f_{1} \\ f_{2} \\ f_{3} \\ f_{4} \\ f_{5} \\ f_{6} \\ f_{7} \\ f_{8} \end{bmatrix} = \begin{bmatrix} \beta \\ \beta \end{bmatrix} \begin{bmatrix} P_{1} \\ P_{2} \\ P_{3} \end{bmatrix}$$
(17)
where
$$\begin{bmatrix} C\alpha\Theta_{3} & S\alpha\Theta_{3} & 0 \\ -S\alpha\Theta_{3} & C\alpha\Theta_{3} & 0 \\ 0 & 0 & 1 \\ (ei-fh)/r & (ch-bi)/r & (bf-ce)/r \\ (fg-di)/r & (ai-cg)/r & (cd-af)/r \\ (dh-eg)/r & (bg-ah)/r & (ae-bd)/r \\ (T\Theta_{4}\Theta_{3})(S\alpha\Theta_{3})L_{2}/L_{3} & (-C\alpha\Theta_{3})(T\Theta_{4}\Theta_{3})L_{2}/L_{3} & (-T\Theta_{4}\Theta_{3})1/L_{3} \\ -S\alpha\Theta_{3}L_{2} & C\alpha\Theta_{3}L_{1} & 1 \end{bmatrix}$$

where

$$b = -S\Theta_{2}$$

$$c = C\Theta_{4}$$

$$d = S\Theta_{2}$$

$$e = C\Theta_{2}$$

$$f = S\Theta_{4}$$

$$g = -L_{2}C\alpha\Theta_{3}S\Theta_{2}+L_{2}S\alpha\Theta_{3}C\Theta_{2}$$

$$h = -L_{2}C\alpha\Theta_{3}C\Theta_{2}-L_{2}S\alpha\Theta_{3}S\Theta_{2}$$

$$i = S(L_{3}C\Theta_{3}-L_{2}C\alpha\Theta_{3})+C(L_{2}S\alpha\Theta_{3}-L_{3}S\Theta_{3})$$

$$r = a(ei-fh)-b(di-fg)+c(dh-eg)$$

Note that the matrix $\begin{bmatrix} \beta \end{bmatrix}$ is a function of the link-lengths and the input angle Θ_2 .

<u>Derivation of Force Transformation Matrix for the Cross-Cognate</u> <u>Mechanism</u>. One of the possibilities for the cognate of a source fourbar (Crank-Rocker) mechanism is that it can be a crossed four-bar (Crank Rocker) linkage. In such case, the orientation of the system forces and element forces vary because of the changed configuration of the cognate as shown in Figure 9. Thus, the force transformation matrix will vary for such a cognate. Referring to the free-body diagrams of the elements of the cognate from Figure 9b, the force transfer matrix is derived as follows:

$$f_1 = -P_1 \cos(\gamma - \Theta_3) + P_2 \sin(\gamma - \Theta_3)$$

$$f_2 = -P_1 \cos(\pi/2 - (\gamma - \Theta_3) -)_2 \sin(\pi/2 - (\gamma - \Theta_3))$$












Figure 9d. Element 4, the Follower Link of the Cognate

$$f_3 = P_3$$

or

$$f_{1} = -P_{1}\cos(\gamma - \Theta_{3}) + P_{2}\sin(\gamma - \Theta_{3})$$

$$f_{2} = -P_{1}\sin(\gamma - \Theta_{3}) - P_{2}\cos(\gamma - \Theta_{3})$$

$$f_{3} = P_{3}$$
(19)

Summing the horizontal forces of the coupler point:

$$P_1 = -f_4 \cos(\Theta_2) + f_5 \sin(\Theta_2) + f_6 \cos(\Theta_4)$$
(20)

Summing the vertical forces on the coupler point:

$$P_2 = -f_4 \sin(\Theta_2) - f_5 \cos(\Theta_2) + f_6 \sin(\Theta_4)$$
(21)

Taking moments about the point P we have

$$P_{3} = \left\{ \cos(\Theta_{2})L_{2}\sin(\gamma-\Theta_{3})+\sin(\Theta_{2})L_{2}\cos(\gamma-\Theta_{3}) \right\} f_{4}$$

$$+ \left\{ \cos(\Theta_{2})L_{2}\cos(\gamma-\Theta_{3})-L_{2}\sin(\Theta_{2})\sin(\gamma-\Theta_{3}) \right\} f_{5}$$
(22)
$$- \left\{ \cos(\Theta_{4})L_{2}\sin(\gamma-\Theta_{3})+\cos(\Theta_{4})L_{3}\cos\Theta_{3}+\sin(\Theta_{4})L_{2}\cos(\gamma-\Theta_{3})+\sin\Theta_{4} \right\}$$

$$L_{3}\sin\Theta_{3} f_{6}$$

Equations (20), (21), and (22) are of the form

$$P_{1} = af_{4} + bf_{5} + cf_{6}$$

$$P_{2} = df_{4} + ef_{5} + ff_{6}$$
(23)

$$P_3 = gf_4 + hf_5 + rf_6$$

Solution of the set of equations yields:

$$f_{4} = \frac{(er-fh)P_{1}+(ch-br)P_{2}+(Pf-ce)P_{3}}{K}$$

$$f_{5} = \frac{(fg-dr)P_{1}+(ar-cg)P_{2}+(cd-af)P_{3}}{K}$$

$$f_{6} = \frac{(dh-eg)P_{1}+(bg-ah)P_{2}+(ac-bd)P_{3}}{K}$$

where

$$K = a(er-fh)-b(dr-fg)+c(dh-eg)$$

Considering the free-body diagram of the coupler alone as shown in Figure 10:

$$f_7 = f_6 \cos(\Theta_3 - \Theta_4)$$

$$f_8 = f_6 L_3 \sin(\Theta_3 - \Theta_4)$$
(25)

may also be written in terms of P_1 , P_2 , P_3 by summing the moments about the point D, as shown in Figure 10.

$$f_{6}L_{3} = \sin(\Theta_{3} - \Theta_{4}) = -L_{2}\sin(\gamma - \Theta_{3})P_{1} - P_{2}L_{2}\cos(\gamma - \Theta_{3}) + P_{3}$$

$$f_{6} = \frac{-L_{2} \sin(\gamma - \Theta_{3})P_{1} - L_{2} \cos(\gamma - \Theta_{3})P_{2} + P_{3}}{L_{3} \sin(\Theta_{3} - \Theta_{4})}$$

Thus

(24)





$$f_{7} = (-L_{2}/L_{3})\cot(\Theta_{3}-\Theta_{4})\sin(\gamma-\Theta_{3})P_{1}-(L_{2}/L_{3})\cot(\Theta_{3}-\Theta_{4})\cos(\gamma-\Theta_{3})P_{2}+\cot(\Theta_{3}-\Theta_{4})P_{3}/L_{3}$$

and

$$f_8 = -L_2 \sin(\gamma - \theta_3) P_1 - L_2 \cos(\gamma - \theta_3) P_2 + P_3$$
(26)

Combining equations (19)(24)(26) into a matrix form, the element forces f_1, f_2, \ldots, f_8 may be derived from the system forces P_1, P_2, P_3 . The following symbolic notations are used:

$$C_{\gamma} \Theta_{3} = \cos(\gamma - \Theta_{3}), \quad S_{\ell} \Theta_{3} = \sin(\gamma - \Theta_{3})$$

$$C_{\Theta_{2}} = \cos(\Theta_{2}), \quad S_{\Theta_{2}} = \sin(\Theta_{2})$$

$$C_{\Theta_{2}} = \cos(\Theta_{3}), \quad S_{\Theta_{3}} = \sin(\Theta_{3})$$

$$C_{\Theta_{4}} = \cos(\Theta_{4}), \quad S_{\Theta_{4}} = \sin(\Theta_{4})$$

$$C_{\Theta_{3}} \Theta_{4} = \cot(\Theta_{3} - \Theta_{4})$$

The force transformation matrix may be represented as



(27)

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where β_{c} is given as:

$$\begin{bmatrix} -C_{Y}\Theta_{3} & S_{Y}\Theta_{3} & 0 \\ -S_{Y}\Theta_{3} & -C_{Y}\Theta_{3} & 0 \\ 0 & 0 & 1 \\ (er-fh)/K & (ch-br)/K & (bf-ce)/K \\ (fg-dr)/K & (ar-cg)/K & (cd-af)/K \\ (fg-dr)/K & (bg-ah)/K & (ae-bd)/K \\ (dh-eg)/K & (bg-ah)/K & (ae-bd)/K \\ -C\Theta_{3}\Theta_{4}YS_{Y}\Theta_{3}L_{2}/L_{3} & -C\Theta_{3}\Theta_{4}C_{Y}\Theta_{3}L_{2}/L_{3} & C\Theta_{3}\Theta_{4}/L_{3} \\ -S_{Y}\Theta_{3}L_{2} & -C_{Y}\Theta_{3}L_{2} & 1 \end{bmatrix}$$

where

 $a = -C\Theta_{2}$ $b = S\Theta_{2}$ $c = C\Theta_{4}$ $d = -S\Theta_{2}$ $e = -C\Theta_{2}$ $f = S\Theta_{4}$ $g = C\Theta_{2}L_{2} SY\Theta_{3}+S\Theta_{2}L_{2} CY\Theta_{3}$ $h = C\Theta_{4}L_{2} CY\Theta_{3}-S\Theta_{2}L_{2} SY\Theta_{3}$ $Y = C\Theta_{4}L_{2} SY\Theta_{3}+C\Theta_{4}L_{3} C\Theta_{3}+S\Theta_{4}L_{2} CY\Theta_{3}+S\Theta_{4}L_{3} S\Theta_{3}$ K = a(er-fh)-b(dr-fg)+c(dh-eg)

<u>Element Flexibility Matrix of the System</u>. The element flexibility matrix for the four link mechanism can be expressed in a diagonal super matrix consisting of the individual element flexibilities as derived in Chapter III.

The element flexibility matrix for a four-link mechanism is an (8x8) diagonal matrix as shown below:

	r .							f (
	L ₂ /A ₂ E ₂	0	0	0	0	0	0	0	
	0	L ₂ ³ /3E ₂ I ₂	L ² /2E ₂ I ₂	0	0	0	0	0	
	0	L ₂ ² /2E ₂ I ₂	L ₂ /E ₂ I ₂	0	0	0	0	0	
[F]=	0	0	0	L ₁ /A ₁ E ₁	0	0	0	0(29)	1
	0	0	0	0	L ³ /3E ₁ I ₁	0	0	0	
	0	0	0	0	0	L ₄ /A ₄ E ₄	0	0	
	0	0	0	0	0	0	L ₃ /A ₃ E ₃	0	
	0	0	0	0	0	0	0	L ₃ /3E ₃ I ₃	
								_	

The following notations are used:

L₁ = input-link length of the source four-bar
L₂ = the coupler extender length
L₃ = the coupler link length
L₄ = the follower link length
A_i = area of cross-section of corresponding link
E_i = modulus of elasticity of corresponding link
I_i = cross-sectional moment of inertia about an axis normal to the plane of the mechanism of the corresponding link.

It is evident that the element flexibility matrix is independent of the configuration of the mechanism, i.e., the input angle.

The element of flexibility matrix for the cognate linkage remains the same except for the following link dimensions:

 cL_1 = input link length of the cognate

 cL_2 = coupler extender length of the cognate

 $cL_3 = coupler link length of the cognate$

 cL_{Δ} = follower link length of the cognate

For both the source and the cognate mechanisms, the base link (fixed link) is considered as rigid since it is grounded. The four-bar and its cognate are considered to be made up of homogeneous metal (aluminum) and each link is of uniform cross-section.

<u>Determining the System Forces</u>. The key interest of the problem is to compute the deflections of the coupler point of the source and its cognate mechanism. The links are assumed mass-less compared to the inertial mass located at path point "P." The external or the generalized forces acting on the system are the horizontal and the vertical inertial forces P_1 and P_2 and an inertial torque P_3 , all located at the path point "P."

The computation of these forces requires first the complete kinematic analysis of the four-bar and its cognate mechanism. A complete kinematic analysis of the source four-bar and its cognate is performed using the "Complex Number Approach" (8).

Using equation (6), i.e., \backslash

$\left[\delta \right] = \left[\beta \right]^{\mathsf{t}} \left[F \right] \left[\beta \right] \left[P \right]$

the deflections of the coupler point for the source and its cognate are determined for this case.

A computer program is developed for this case, and is given in Appendix B. A numerical example problem for this case is presented.

Case II: Mass at Each Joint of the Linkages

The second case differs from the first case in the respect that now each element has a concentrated or disc mass located at each joint as shown in Figure 11. There are eight system forces (P_1, P_2, \ldots, P_8) instead of the three system forces (P_1, P_2, P_3) in the first case. The other five system forces directed in the five element coordinate directions are associated with elements 1, 3, 4. These eight system forces represent the inertia forces of each respective element.

The objective is to compute the deflections at the path-point of the four-bar and its cognate mechanism. For this purpose, equation (6) is still valid excep with the following change in matrix dimensions:

P: the system force matrix is an (8×1) matrix instead of (3×1) as in Case I. However, the force-transformation matrix will vary and is a new (8×8) matrix. The flexibility matrix for the elements is independent of the configuration of the mechanism and thus remains the same as derived for Case I, since deflections at the coupler point of interest $\left[\beta \right]^{t}$ matrix remains the same.

The new force transformation matrix for the source four-bar is of the form:









where $\begin{bmatrix} \beta_1 \end{bmatrix}$ is the force transformation matrix from Case I. Since the cognate configuration is crossed, the new force transformation matrix for this case differs from the source linkage and is derived as follows:

where Θ_3^{\star} - is the coupler angle for the cognate.

Where $\begin{bmatrix} \beta_1 \\ cog \end{bmatrix}$ is the force-transfer matrix for the cognate from Case I.

The deflections at the coupler point can be represented as:

$$\begin{bmatrix} \delta_{1} \\ \delta_{2} \\ \vdots \\ \delta_{3} \\ \vdots \\ \delta_{8} \end{bmatrix} = \begin{bmatrix} 3x8 \\ \beta \\ 2 \end{bmatrix} \begin{bmatrix} 8x8 \\ \beta \\ F \end{bmatrix} \begin{bmatrix} 8x8 \\ \beta \\ 2 \end{bmatrix} \begin{bmatrix} 8x1 \\ \beta \\ 2 \end{bmatrix}$$
(32)

where $\begin{bmatrix} \beta_2 \end{bmatrix}^t \text{ and } \begin{bmatrix} \beta_2 \end{bmatrix}$ and $\begin{bmatrix} P \end{bmatrix}$ are different for source and cognate as derived above.

The method of computing the deflection is general. This can be demonstrated by adding any number of inertia and/or external forces to the system. For example, if there are twenty system forces and fifteen element coordinates, then the system force matrix is (20x1), i.e., P_j, $j=1,2,3,\ldots,20$. The corresponding force transformation matrix transferring fifteen element forces to system forces becomes (15x20). The fifteen element flexibilities can be coupled to form a (15x15) element flexibility matrix. Then, the fifteen element deflections can be expressed as:

$$\begin{bmatrix} d_{1} \\ d_{2} \\ d_{3} \\ \vdots \\ d_{15} \end{bmatrix} = \begin{bmatrix} F \\ (15x15) \\ F \\ (15x20) \end{bmatrix} \begin{bmatrix} \beta \\ (15x20) \\ P \\ (20x1) \end{bmatrix}$$
(33)

In the example problem, the mass of each link is computed and assumed to be lumped at each joint. The deflections of the coupler

point are calculated; however, by this approach, the deflections of each element can be calculated. Listing of the computer program for the second case is given in Appendix C.

Case III: Distributed Mass Model

The third case describes the computation of the deflections induced in the members of the mechanism by considering the mass of each link to be distributed in the form of sub-elements. For the four-bar under consideration, the deformation of the coupler link is due to its own inertia since Elements 1 and 4 (the input and the follower links) may only cause the coupler to deflect as a rigid body.

Considering the mass to be distributed in the form of sub-elements in the coupler extender which is of primary importance, deflections at each point can be calculated by considering the mass being made up of elemental masses located at the infinite tips in an increasing trend of length of the extender, as in Figures 12a and 8b. The system forces P_j , j=1,...,n (where n is the number of system forces) can be computed.

However, for practical computation, if the extender is divided into five parts with mass located at each node as shown in Figure 12c, there are fifteen system forces. The number of system forces increases with the number of nodes selected for study.

The system force matrix $\begin{bmatrix} P_j \end{bmatrix}$ is a (15x1) matrix for this case. Since Element 2 is subdivided into five elements, the element flexibility matrix $\begin{bmatrix} F^* \end{bmatrix}$ varies for both source and cognate mechanism, and is a (40x40) matrix, as given below:



Figure 12a. Distributed Mass Model for Coupler







Figure 12c. Location of Masses and Corresponding Subelement Lengths

	r ·		•		T
	(8x8) ^F 1	0	0	0	0
	0 :	(8x8) F ₂	0	0	0
[F*]=	0	0	(8x8) F ₃	0	0
	0	0	0	(8x8) F ₄	0
•	0	0	0	0	(8x8) F ₅

where F_1 is the same as [F] in Case I where F_2 is the same as [F] in Case I but with L_{21} , similarly where F_5 is the same as [F] in Case I but with L_{24}

The division of Element 2 into five sub-elements contributes in the increase in number of elemental forces, f_1 , f_2 , f_3 ,..., f_{40} . The force transformation matrix is a (40x15) matrix. For the source fourbar mechanism, the force transfer matrix is a diagonal matrix with five sub-force transfer matrices as shown:

$$\begin{bmatrix} \beta^{+} \end{bmatrix} = \begin{bmatrix} \beta_{1} & 0 & 0 & 0 & 0 \\ 0 & \beta_{2} & 0 & 0 & 0 \\ 0 & 0 & \beta_{3} & 0 & 0 \\ 0 & 0 & 0 & \beta_{4} & 0 \\ 0 & 0 & 0 & 0 & \beta_{5} \end{bmatrix}$$

where $\begin{bmatrix} \beta_1 \end{bmatrix}$ to $\begin{bmatrix} \beta_5 \end{bmatrix}$ are similar to $\begin{bmatrix} \beta \end{bmatrix}$ in Case I, except with lengths L_2 , L_{21}, \ldots, L_{24} β_1 to β_5 each time calculated with different lengths

 L_2 , L_{21} , L_{22} , L_{23} , L_{24} , respectively.

Thus, for each source and its cognate, the deflections of the coupler extender at the five selected points are evaluated by the relation:

$$\begin{bmatrix} \delta_{1} \\ \vdots \\ \delta_{15} \end{bmatrix} = \begin{bmatrix} (15x40) \\ \beta \end{bmatrix}^{t} \begin{bmatrix} (40x40) \\ F \end{bmatrix} \begin{bmatrix} (40x15) \\ \beta \end{bmatrix} \begin{bmatrix} (15x1) \\ P \end{bmatrix}$$

The methodology developed for the three cases to calculate the deflections of the coupler point is demonstrated on a four-bar (Crank-Rocker) mechanism and its crossed cognate is shown in Figures 13a and 13b. The computer program for this case is given in Appendix D.

The results and conclusions are presented in the next chapter.





Data for Numerical Example				
Input-link length	L_1	=	10	in
Coupler link length	L ₃	=	30	in
Coupler extender length	L ₂	=	10	in
Follower link length	L ₄	=	25	in
Fixed or grounded link length	L ₅	=	30	in
Uniform circular cross-sectional area				
of all links	А	=	0.1	9634
Rigid angle between coupler and extender	α	=	60	degr
Modulus of elasticity for aluminum	Е	=	10>	(10 ⁶
Cross-sectional moment of inertia	I	=	0.0	0306
Input link velocity	ω2	=	300) rpi

Mass at coupler Point for Case I

4 sq in rees psi 6 in⁴ = 300 rpm Mg = 2[°]1bf





Data for Numerical Example

Input link length	$^{cL}1$
Coupler extender length	cL2
Coupler link length	cL3
Follower link length	cL4
Ground link length	cL ₅
Rigid coupler angle	γ

From Figure 13a, if $K = L_2/L_3$ using the parallelogram properties, the link lengths and the angles are calculated as follows:

$$CL_{4} = SQRT \quad L_{2}^{2} + L_{3}^{2} - 2L_{2}L_{3}cos(L)$$

$$CL_{3} = L_{4} \times CL_{4}/CL_{3}$$

$$CL_{2} = K.L_{4}$$

$$CL_{1} = L_{1} \times CL_{4}/CL_{3}$$

$$CL_{5} = \sqrt{(KL_{5})^{2} - 2K.L_{5}.L_{5}.cos(\alpha)}$$

$$\gamma = 101 \text{ degrees}$$

CHAPTER V

RESULTS AND CONCLUSIONS

This thesis presents a general method of kineto-elasto dynamic analysis, which may be applied to various planar mechanisms with elastic links. The flexibility method of structural analysis is applied to mechanisms. The mechanism is frozen in various configurations and analyzed as an instantaneous structure with elastic members.

The flexibility approach described above 'is demonstrated on a planar four-bar linkage and its coupler cognate mechanism to determine the elastic deflections of the coupler point through a steady state cycle of motion. Three cases of increasing level of accuracy are considered:

 Completely elastic system where the mass of links is negligible in comparison to the inertial mass at the coupler point.

2) Each element has its mass located at the joints of the mechanisms.

3) Mass of each element distributed in the form of sub-elements.

Computer programs are developed for the above three cases given in Appendices B, C, and D.

For the above three cases, a planar four-bar Crank-Rocker mechan ism which has a crossed cognate is selected as an example problem. Tables I, II, and III present the rigid path of the coupler course and the actual path when elastic deflections are added to it. For all of

TABLE I

MASS AT PATH POINT (Case I)

Input Link Rotation	Coupler Point Coordinates in Rigid Mode	Source-Linkage Deflections	Source Coupler Points in K.E.D. Mode	Cognate-Linkage Deflections	Cognate Coupler Points in K.E.D. Mode	
Degrees	X Y	ΔΧ ΔΥ	X _{new} Y _{new}	ΔΧ ΔΥ	X Y new	
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280	5.648 9.004 6.637 13.033 6.234 16.328 4.470 18.648 1.710 19.849 -1.571 19.845 -4.904 18.655 -7.871 16.418 -10.145 13.382 -11.507 9.873 -11.846 6.261 -11.163 2.923 -9.561 0.223 -7.242 $-1.515-4.478$ -2.026	$\begin{array}{ccccccc} -0.238 & -0.539 \\ -2.255 & -3.486 \\ -3.589 & -4.197 \\ -3.791 & -3.670 \\ -3.215 & -2.804 \\ -2.255 & -1.891 \\ -1.179 & -1.003 \\ -0.171 & -0.156 \\ -0.655 & -0.660 \\ 1.244 & 1.465 \\ 1.579 & 2.276 \\ 1.664 & 3.079 \\ 1.526 & 3.823 \\ 1.230 & 4.433 \\ 0.893 & 4.820 \end{array}$	5.410 $8.4654.382$ $9.5472.645$ $12.1310.679$ $14.978-2.045$ $17.045-3.826$ $17.954-6.083$ $17.652-8.042$ $15.992-10.800$ $12.722-10.263$ $11.338-10.267$ $8.537-9.519$ $6.002-8.035$ $4.046-6.012$ $2.918-3.585$ 2.794	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	5.611 8.437 6.372 11.722 5.874 14.854 4.193 17.253 1.588 18.584 -1.533 18.732 -4.738 17.722 -7.636 15.695 -9.914 12.889 -11.356 9.619 -11.839 6.253 -11.351 3.172 -9.966 0.748 -7.839 -0.701 -5.179 -0.939	
300 320 340 360	-1.574 -1.131 1.209 1.218 3.695 4.812 5.648 9.004	0.669 4.867 0.671 4.333 0.671 2.641 -0.238 -0.539	-9.905 3.736 1.880 5.551 4.366 7.453 5.410 8.465	-0.643 1.268 -0.385 1.680 -0.066 0.513 -0.037 -0.567	-2.217 0.137 0.824 2.898 3.629 5.325 5.611 8.437	

TABLE II

MASS AT EACH JOINT (Case II)

Input Link Rotation	Coupler Point Coordinates in Rigid Mode	Source-Linkage Deflections	Source Coupler Points in K.E.D. Mode	Cognate-Linkage Deflections	Cognate Coupler Points in K.E.D. Mode	
Degrees	X Y	ΔΧ ΔΥ	X _{new} Y _{new}	ΔΧ ΔΥ	X _{new} Y _{new}	
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340	5.648 9.004 6.637 13.033 6.234 16.328 4.470 18.648 1.710 19.849 -1.571 19.845 -4.904 18.655 -7.871 16.418 -10.145 13.382 -11.507 9.873 -11.846 6.261 -11.163 2.923 -9.561 0.223 -7.242 $-1.515-4.478$ $-2.026-1.574$ $-1.1311.209$ 1.218 3.695 4.812	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	5.522 8.942 6.386 12.959 5.969 16.289 4.274 18.637 1.609 19.848 -1.562 19.845 -4.898 18.656 -7.750 16.422 -9.989 13.394 -11.332 9.900 -11.664 6.307 -10.984 2.99 -9.392 0.311 -7.090 $-1.414-4.349$ $-1.922-1.472$ $-1.0411.276$ 1.275 3.696 4.812	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	

TABLE III

DISTRIBUTED MASS MODEL (Case III)

Input Link Rotation	Coupler Point Coordinates in Rigid Mode		Source-Linkage Deflections		Source Point K.E.D.	Coupler ts in Mode	Cognate-Linkage Deflections		Cognate Coupler Points in K.E.D. Mode	
Degrees	Х	Y	۵X	ΔY	X _{new}	Y new	۵X	ΔΥ	Xnew	Y _{new}
0	5.648	9.004	-0.141	-0.090	5.507	8.914	0.001	0.072	5.649	9.076
20	6.634 1	3.033	-0.255	-0.115	6.382	12.918	-0.004	-0.044	6.630	12.989
40	6.234 1	6.328	-0.259	-0.051	5.975	16.277	-0.019	-0.118	6.215	16.010
60	4.470 1	8.648	-0.199	-0.008	4.271	18.640	-0.043	-0.112	4.427	18.536
80	1.710 1	9.849	-0.113	0.002	1.597	19.851	-0.057	-0.091	1.653	19.758
100	-1.571 1	9.845	-0.025	-0.002	-1.596	19.843	-0.053	-0.068	-1.624	19.777
120	-4.904 1	8.655	0.053	-0.007	-4.851	18.649	-0.038	-0.046	-4.942	18.609
140	-7.871 1	6.418	0.113	-0.003	-7.757	16.415	-0.019	-0.024	-7.890	16.394
160	-10.145 1	3.382	0.154	0.010	-9.991	13.392	-0.001	-0.003	-10.146	13.379
180	-11.507	9.873	0.176	0.032	-11.331	9.905	0.012	0.020	-11.495	9.893
200	-11.846	6.261	0.181	0.057	-11.665	6.318	0.018	0.042	-11.828	6.303
220	-11.163	2.923	0.176	0.078	-10.987	3.001	0.017	0.061	-11.146	2.984
240	-9.561	0.223	0.166	0.091	-9.395	0.314	0.012	0.076	-9.549	0.299
260	-7.242 -	-1.515	0.157	0.100	-7.085	-1.415	0.005	0.089	-7.237	-1.426
280	-4.478 -	-2.026	0.145	0.107	-4.334	-1.919	-0.004	0.101	-4.482	-2.025
300	-1.574 -	-1.131	0.125	0.104	-1.450	-1.027	-0.014	0.111	-1.588	-1.020
320	1.209	1.218	0.091	0.080	1.301	1,298	-0.019	0.117	1,190	1.335
340	3,695	4.812	0.014	0.017	3.710	4.829	-0.012	0.114	3,683	4.926
360	5.648	9.004	-0.141	-0.090	5.507	8.914	0.001	0.072	5.649	9.076

the cases described, graphs are plotted for two different speeds of the input link, i.e., at 300 rpm and 400 rpm to observe the major change in deflections with an increasing speed (Appendix A).

The following are the observations:

1) It is observed that with an increase of 100 rpm in the speed of the input link, the elastic deflections were nearly doubled.

2) Maximum deflections occur in the second half of the cycle of motion of the input link.

3) The increase in deflections with the increase in speed of the input rotation shows that there is a critical speed where links of a mechanism assembly fail to obey Hook's law, and the deformations induced will be permanent and will not balance with the cycle of motion.

4) The angular velocity of the input links for both the source and its cognate is assumed to be constant. Any fluctuation in speed causing acceleration will affect the deflections of the coupler path in X and Y directions considerably and the rotation in Z direction, with reference to a fixed reference plane.

5) The difference in the deflections of the source and its cognate for each case (Tables I, II, and III) clearly justifies that the parallelogram property of the construction of cognates does not hold good in K.E.D. mode. Thus, finding a coupler cognate in K.E.D. mode becomes a synthesis problem.

6) The accuracy of the computed deflections depends on the following factors:

- a) the number and choice of the mechanism elements.
- b) the size of the increment between each successive input rotation.

c) the mass model utilized.

• d) the accuracy of the system forces.

The first three factors depend on the time available to the designer and the computer time.

The results of this thesis demonstrate the need for incorporating kineto-elastodynamic effects in overall mechanical design analysis. Further, the effects of induced elasticity in linkages can be overcome by the K.E.D. "re-synthesis" procedure. These considerations are of utmost importance wherever high speed and accuracy are the criteria for design.

This thesis sets a base for undertaking some of the possible research studies.

1) K.E.D. analysis and synthesis of elastic four-bar linkage with arbitrary mass assigned to each link.

2) K.E.D. analysis and synthesis of planar four-bar with a variable mass, where the mass is added and removed during certain parts of the mechanism cycle.

3. K.E.D. analysis based on the fluctuating angular velocity of the input link.

4) Extension of the idea of flexibility approach to spatial linkages.

5) K.E.D. re-synthesis of mechanisms to account for weight minimization, balancing, and stability.

6) Compilation of K.E.D. coupler-curve atlas which will be an improvement over the Hrones and Nelson atlas, accounting for the elasticity.

7) The effect of clearance in the joints of the mechanisms considering the joints to be elastic.

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APPENDIX A

GRAPHS - INPUT-LINK ROTATION VS.

ELASTIC DEFLECTIONS

SOURCE MECHANISM - CASE I



Input Link Rotation vs. Elastic Displacement of the Coupler Point in X-Direction

SOURCE MECHANISM - CASE I



Input Link Rotation vs. Elastic Displacement of the Coupler Point in Y-Direction

SOURCE MECHANISM - CASE I



Input Link Rotation vs. Elastic Rotation in Z Direction

COGNATE MECHANISM - CASE I



Input Link Rotation vs. Elastic Displacement of the Coupler Point in X Direction









COGNATE MECHANISM - CASE I

SOURCE MECHANISM - CASE II



Input Link Rotation vs. Elastic Displacement of the Coupler Point in X-Direction

SOURCE MECHANISM - CASE II



Input Link Rotation vs. Elastic Displacement of the Coupler Point in Y-Direction
SOURCE MECHANISM - CASE II



Input Link Rotation vs. Elastic Rotation in Z Direction

COGNATE MECHANISM - CASE II



Input Link Rotation vs. Elastic Displacement of the Coupler Point in X-Direction

COGNATE MECHANISM - CASE II



Input Link Rotation ys. Elastic Displacement of the Coupler Point in Y-Direction

COGNATE MECHANISM - CASE II



Input Link Rotation vs. Elastic Rotation in Z-Direction

SOURCE MECHANISM - CASE III



Input Link Rotation vs. Elastic Displacement of the Coupler Point in X-Direction

SOURCE MECHANISM - CASE III



Input Link Rotation vs. Elastic Displacement of the Coupler Point in Y-Direction

SOURCE MECHANISM - CASE III



Input Link Rotation vs. Elastic Rotation in Z-Direction

COGNATE MECHANISM - CASE III



Input Link Rotation vs. Elastic Displacement of the Coupler Point in X-Direction

COGNATE MECHANISM - CASE III



Input Link Rotation vs. Elastic Displacement of the Coupler Point in Y-Direction

COGNATE MECHANISM - CASE III



Input Link Rotation vs. Elastic Rotation in Z-Direction

APPENDIX B

CASE I: LUMPED MASS AT THE PATH POINT

\$JOB FIME =15,NOSUBCHK ******************** C C **** £. ******* K.E.D. ANALYSIS OF THE SOURCE FOUR-BAR MECHANISM. ****** C Ć. ** C. * CASE I * C * ____ _ * C. **** t, C. xX. C. . s. THIS PROCEDURE COMPUTES THE DEFLECTIONS AT THE COUPLER POINT. * (. *THE MASS OF THE FOUR-BAR IS ASSUMED TO BE NEGLIGIBLE COMPARED TO * *THE INERTIAL MASS AT THE COUPLER POINT. ſ С * THE MASS 'M'=2 POUNDS IS LOCATED AT THE POINT 'P'. С С С **** С × С --- THE FOLLOWING ARE THE DIMENSIONS OF THE FOUR-BAR:----C. * · * С *L1---- THE INPUT LINK LENGTH OF THE SOURCE FOUR-BAR MECHANISM. 4 *L2---- THE COUPLER EXTENDER LENGTH ATTACHED RIGIDLY TO COUPLER. С * *LO---- THE COUPLER LINK LENGTH OF THE SOURCE FOUR-BAR MECHANISM. * Ċ. *L4---- THE OUT PUT LINK LENGTH OF THE SOURCE FOUR-BAR MECHANISM. * C. С *L5---- THE FIXED LINK LENGTH OF THE SOURCE FOUR-BAP MECHANISM. Ċ 25 С *ALP---- THE RIGID ANGLE BETWEEN THE COUPLER AND EXTENDER. С *T2---- THE INPUT ANGLE IN RADIANS. *T3---- THE COUPLER ANGLE IN RADIANS. C. С *T4---- THE DUT-PUT ANGLE IN KADIANS. *0M2---- THE ANGULAR VELOCITY OF THE INPUT LINK IN RAD/SEC. C ± С *JM3---- THE ANGULAR VELOCITY OF THE COUPLER IN RADIANS/SEC. * C *UM4---- THE ANGULAR VELOCITY OF THE OUTPUT LINK IN RADIANS/SEC. #ALPH2---- THE ANGULAR ALC. OF INPUT IS CONSIDERED AS ZERO. С *ALPH3---- THE ANGULAR ACC. OF THE COUPLER LINK IN RAD/SEC/SEC. С С *ALPH4---- THE ANGULAR ACC. OF THE OUTPUT LINK IN RAD/SEC/SEC. £ *XPA---- THE HURIZANIAL CUMPONENT OF ACC. OF THE PF."P". C ± *YPA---- THE VERTICAL COMPONENT OF THE ACC. OF PT."P". С C *XPE---- THE HURIZANTAL COMP. OF THE FORCE AT THE PT."P". ** *YPE---- THE VERTICAL COMP. OF THE FURCE AT THE PT."P". C С ÷ C ****** Ċ С *THE FULLOWING DATA MUST BE SUPPLIED TO THE PROGRAM C. C С *1. THE LINK LENGTHS: U1,L2,L3,L4,L5 *2. THE ANGULAR VELOCITY OF THE INPUT LINK "DM2" C C *3. THE ANGULAR ACCELERATION OF THE INPUT LINK #ALPH2# *4. THE CRUSS-SECTIONAL AREA UD THE LINKS "CA" C *5. THE CROSS-SECTIONAL MOMENT OF INERTIA "MI" C. *6. THE MUDULUS OF ELASTICITY OF THE LINK MATAFIAL "ME" C. C ANDIL: THE LINK LENGTH L2 IS THE COUPLER EXTENDER Ċ Ċ. *-----*NUTE: THE SUBROULINES BATEA&MPRD ARE TO BE EXTERNALY SUPPLIED. C ·---Ċ * ÷. C C. *

1 DUDREF PRECISION LI, L2, L3, L4, L5, K1, K2, K3, K4, K5, DEDS, D510, DAIAN, *AA, 88, CC, DD, FF, FF, A1, 81, C1, D1, F1, F1, F1, F1, F1, F1, CX, SX, CTX, DSQRT, *T2+T3+T4+ALP+LA+MT+ME+JM2+UM3+JM4+AJ+BJ+CJ+DJ+EJ+EJ+EJ+ALPH2+ALPH3+ *ALPH4, DLOT, P1, XP, YP, XX, YY, NXP, NYP 2 DIMENSION A(64), B(64), B(64), S(37,2), 4(37,2) 3 1 1= 10.0 4 1.2=10.0 ۲, L3=30.0 1.4=25.) 6 1 15=30.0 K1=15/11 ы C_{i} K2=L5/L4 10 K3=(L1*L1-L3*L3+L4*L4+L5*L5)/(2.0*L1*L4) 11 K4=L57L3 K5=(L4*L4+L5*L5-L1+L1-L3*L3)/(2.0*L1*L3) 12 13 P1=3.142857143 C N---- THE SPEED OF RELATION OF THE INPUT LINK. 14 N=400.0 15 UM2=(2.0*P[*N]/60.0 10 WRITE(6,100) 17 100 FURMAL(1H1.9X. * DEGREES*, 13X, *X-DISP.UF P*, 3X, *Y-JISP.UF P*, 10X, *Z-*RUT.UF P!) 10 P2=-10.0 5 P2=P2+10.0 19 T2=(P2#2.0*P1)/(360.0) 20 21 AA=DCUS(12)+K3-K1-(K2*UCUS(12)) 22 88=+2.0*051N(T2) 23 CC=K1+K3-(1.0+K2)*DUOS(T2) 24 00= (K4*0C05(12))+0C05(12)+K5-K1 $bb = -2 \cdot 0 \neq DSIN(12)$ 25 20 FF= (K4*0005(12)) - 0005(12) + K5+K1 27 13=2.0*(DATAN((~EL-DSJRT(FE*EE-4.0*D0*FF))/(2.0*0))) 28 T4=2.0*(DATAN((-88-DSORT(BB*88-4.0*AA*CC))/(2.0*AA))) 29 CX=DU05(T4-T3) 30 SX = DSIN(14 - T3)CFX=CX/SX 11 ALP=1.702782545 32 3 3 XP=(L1#0COS(12))+(L2#0GUS(ALP+T3)) YP=(L1*051N(12))+(L2*051N(ALP+T3)) 34 35 .143=(L1*0M2*0S1N(T4-T3))/(L3*0S1N(T3-T4)) UM4=(L1*OM2*DSIN(12-T3))/(L4*DSIN(T4-T3)) 36 AJ=14*0 STN(14) 37 58 6J=L3*951N(T3) 30 _CJ=(L1*UM2*UM2*DCUS(T2))+(L3*UM3*UM3*DCUS(T3))-(L4*UM4*)M+*DCUS(T4 ¥)) 40 DJ=L4*06US(T4) + J=L3*0C0S(T3) 41 ドリニ(し4キロM4キロM4キロS1N(T4))→(L1キロM2*DM2*DS1N(T2))→(L3キロM3キロM3キDS1N(T3)) 4.2 *)) 13 ALPH2=0.0 44 ALPH3=(UJ#DJ-AJ#FJ)/(AJ#FJ-AJ#DJ) 45 AL PH4= (CJ*EJ-BJ*EJ)/(AJ*EJ-BJ*DJ) XYA == (11×0M2×0M2×0C0S(T2)) - (L1×AL2H2×0SIN(T2)) - (L2×0M3×0M3×0C0S(40 *ALP+13))-(L2*ALPH3*D5[N(ALP+13)) YPA=([1*ALPH2*DLUS(12))-([1*0M2*0M2*051N(T2))+([2*ALP+3*0C05(ALP+ 41 >13))-(E2*UM3*OM3*OSIN(ALP+T3)) 48 XPF=XPA*2.0/(12.0*32.173) 49 YPE -YPA#2.0/(12.0# 32.178) 50 A1=0C05(T2) B1 = -PSIN(T2)51

C1 = DC (S (T4) 52 53 01=051N(T2) 54 E1 = CCUS(T2)44 F1 = DS1N(T4)56 G1=-(1 2*0LUS(ALP+T3)*0CUS(T2))+(L2*0SIN(ALP+T3)*0CQS(T2)) 57 H1=-(L2*OCOS(ALP+13)*OCOS(T2))-(L2*OSIN(ALP+T3)*OSIN(T2)) 55 11=D51N(T4)*((12*DCUS(T3))-(L2*DC0S(ALP+T3)))+DC0S(T4)*((L2*DS1N(#ALP+T())-(L3*0S1N(T3))) R1=(A1*(E1*11-F1*H1))-(B1*(D1*11-F1*G1))+(C1*(D1*H1+F1*G1)) 59 THE FORLE TRANSFORMATION MATRIX. ί 60 A(1)=DCUS(T3+ALP) A(2)=+OSIN(T3+ALP) 61 A(3)=0.0 62 A(4)=((F1*11)-(F1*H1))/R1 6.3 A(5) = ((F1 * G1) - (D1 * I1))/R164 A(6)=((U1*H1)-(L1*G1))/R1 65 A(7)=CTX*D51N(T3+ALP)*(L2/L3) 66 67 A(8) = -(DSIN(13+ALP)) + L268 A(9)=05IN(13+ALP) 65 A(10) = DCOS(T3 + ALP)A(11) = 0.010 71 A(12)=((C1*H1-B1*I1))/R1 12 $A(13) = ((A1 \times I1) - (C1 \times G1))/R1$ 13 A(14)=((B1*G1)-(A1*H1))/RL A(15)=-(DCOS(T3+ALP))*CTX*(L2/L3) 14 115 A(16) = 0C0S(T3+ALP) *L2 16 A(17) = (1, 0)17 A(18) = 0.078 A(19)=1.0 70 A(20)=((81*F1)-(01*E1))/R1 30 $A(21) = ((C1 \neq D1) - (A1 \neq I))/R1$ A(22)=((A1*E1)-(B1*D1))/R1 61 A(23) = -CTX/L382 A(24)=1.0 33 84 N=3 35 M= 3 С *TRANSPOSING THE FORCE TRANSFORMATION MATRIX(BETA). 80 CALL GMTRA(A.R.N.M) *TRANSPOSED FORCE TRANSFER MATRIX IS MULTIPLIED BY FLEXIBILITY MAT* C. C *RIX AND THE RESULT IS STORED IN R. 37 00 55 1=1,24 88 >> A(I)=R(1) Ĉ. *ALE LINKS ARE OF UNIFORM UIRCULAR CROSS-SECTION OF DIA.=0.5 IN. \$ ſ. C C *"CA"-URDSS-SECTIONAL AREA OF ALL LINKS. z С, 39 LA= 0.1903495408 С. * "ME "- YOUNGS MUDULUS OF ELASTICITY FOR THE MATARIAL ALUMUNIUM. С Ċ 20 ME = 10000000.0 C, AUMIU-URDSS-SECTIONAL MOMENT OF INERTIA. ú ĉ M1=0.0030679615 11 C #IHE FLUXIBILITY MATRIX"(F) ". 3(1)=L2/(LA*ML) 92 93 0.3 10 1=2.9 94 10 5(1)-0.0

95	B(10)=(L2*L2*L2)/(3.0*ME*M1)		
26	U(11)=(L2≠L2)/(2.U≠ME*MI)		
97	$D_{11} = 12, 17$		
98	11 3(1)=0.)		
44	(18)=(12*12)/(2.U*ME*ME)		
100	H(1.9) = (22.4 M + xM)		
1.01	0 + 12 + 1 - 20 + 27		
101			
107			
103	R(28)=L1/(CA*M))		
104	$011 \ 13 \ 1=29.36$		
105	13 B(1)=0.0		
106	B(37)≈(L1×L1×L1)/(3.0×CA×ME)		
107	UU 14 (=38,45		
103	14 B(I)=0.0		
109	B(46)=L4/(CA*ML)		
110	(1) 15 1=47.54		
111	15 8(1)=0.0		
112	B(55)=1 1/(CA#M())		
112	00.16.1+56.62		
112			
114			
115	B(04)=L3/(3.0*ME*MI)	1	
116	N = 3		
117	M= B	•	
118	MS A =0		
119	MSB=0		
120	L≃B		
121	CALL MPRD(A, B, K, N, M, MSA, MSB, L)		
	C		
	C +THE PRODUCT R IS MULTIPLIED BY THE FU	DRUE TRANSFER MATRI	Χ.
122	D_{1} 66 $1=1,24$	•	
122 123	$\begin{array}{c} (b) & 66 & 1=1,24 \\ 0.5 & A(1) = R(1) \end{array}$		
122 123	D.] 66 (=1,24 υ5 A(1)=R(1) C		
122 123	0.) 66 1=1,24 05 A(1)=R(1) C ====================================	•	
422 123	D.) 66 I=1,24 65 A(I)=R(I) C C = #THE FURCE TRANSFER MATRIX C	•	
122 123	D.) 66 1=1,24 65 A(1)=R(1) C C #THE FURCE TRANSFER MATRIX C B(1)=DCOS(T3+A)P)		
122 123 124	D.] 66 1=1,24 05 A(I)=R(I) C C #THE FORGE TRANSFER MATRIX C B(I)=DCOS(T3+ALP) B(2)=-DSIN(T3+ALP)		
122 123 124 125	0.3 66 1=1,24 0.5 A(1)=R(1) C C *THE FORGE TRANSFER MATRIX C B(1)=DCOS(T3+ALP) B(2)=-DSIN(T3+ALP) d(3)=0.0		
122 123 124 125 126	0.) 66 1=1,24 65 A(1)=R(1) C C *THE FORCE TRANSFEW MATRIX C B(1)=DCOS(T3+ALP) B(2)=-DSIN(T3+ALP) B(3)=0.0 P(6)=+11)=(E++11)/(P)		
122 123 124 125 126 127	<pre>D.1 66 1=1,24 65 A(1)=R(1) C C *THE FURCE TRANSFEW MATRIX C B(1)=DCOS(T3+ALP) B(2)==DSIN(T3+ALP) B(3)=0.0 B(4)=((E1*11)-(F1*H1))/R1 B(5)=((E1*11)-(F1*H1))/R1</pre>		
122 123 124 125 126 127 128	<pre>D.1 66 1=1,24 65 A(1)=R(1) C = *IHE FURCE TRANSFER MATRIX C B(1)=DCOS(T3+ALP) B(2)==DSIN(T3+ALP) B(3)=0.0 B(4)=((E1*11)=(F1*H1))/R1 B(5)=((F1*G1)=(01*T1))/R1 B(5)=((F1*G1)=(01*T1))/R1</pre>		
122 123 124 125 126 127 128 129	<pre>().) 66 i=1,24 ().6 A(1)=R(1) C C *THE FORCE TRANSFER MATRIX C B(1)=DCOS(T3+ALP) B(2)=-DSIN(T3+ALP) B(3)=0.0 D(4)=((E1*11)-(F1*H1))/R1 B(5)=((F1*G1)-(D1*T1))/R1 B(6)=((D1*H1)-(E1*G1))/R1</pre>		
122 123 124 125 126 127 128 129 130	 (1) 36 1=1,24 (5) A(1)=R(1) (7) *THE FORCE TRANSFER MATRIX (8) (1)=DCOS(T3+ALP) (8) (2)=-DSIN(T3+ALP) (3)=0.0 (4)=((E1*L1)-(F1*H1))/R1 (5)=((F1*G1)-(D1*T1))/R1 (6)=((D1*H1)-(E1*G1))/R1 (7)=(TX*DSIN(T3+ALP)*(L2/L3) 		
122 123 124 125 126 127 128 129 130 131	<pre>().) 66 1=1,24 65 A(1)=R(1) C = *IHE FORCE TRANSFEW MATRIX C B(1)=DCOS(T3+ALP) B(2)=-DSIN(T3+ALP) B(3)=0.0 B(4)=((E1*L1)-(F1*H1))/R1 B(5)=((E1*L1)-(F1*H1))/R1 B(6)=((D1*H1)-(E1*G1))/R1 B(6)=((D1*H1)-(E1*G1))/R1 B(6)=(DSIN(T3+ALP))*L2</pre>		
122 123 124 125 126 127 128 129 130 131 132	<pre>().) 66 1=1,24 65 A(1)=R(1) C C *THE FURCE TRANSFEW MATRIX C B(1)=DCOS(T3+ALP) B(2)=-OSIN(T3+ALP) B(3)=0.0 B(4)=((E1*11)-(F1*H1))/R1 B(6)=((E1*11)-(F1*H1))/R1 B(6)=((D1*H1)-(E1*G1))/R1 G(7)=(TX*DSIN(T3+ALP))*(L2/L3) B(0)=-(DSIN(T3+ALP))*L2 B(9)=DSIN(T3+ALP)</pre>		
122 123 124 125 126 127 128 129 130 131 132 133	(b) $366 1=1,24$ (c) $A(1)=R(1)$ C C *THE FURCE TRANSFER MATRIX C B(1)=DCOS(T3+ALP) B(2)=-DSIN(T3+ALP) B(3)=0.0 B(4)=((E1*11)-(F1*H1))/R1 B(5)=((F1*G1)-(O1*T1))/R1 B(6)=((D1*H1)-(E1*G1))/R1 B(6)=((D1*H1)-(E1*G1))/R1 B(6)=((D1*H1)-(E1*G1))/R1 B(6)=(D1*H1)-(E1*G1)/R1 B(6)=(D1*H1)-(E1*G1)/R1 B(3)=(DSIN(T3+ALP))*(L2/L3) B(3)=DSIN(T3+ALP) B(1)=DU(DS(T3+ALP))		
122 123 124 125 126 127 128 129 130 131 132 133 134	 (a) 1 26 1=1,24 (b) A(1)=R(1) (c) *THE FORCE TRANSFER MATRIX (c) B(1)=DCOS(T3+ALP) (d) 2)==DSIN(T3+ALP) (d) 3)=0.0 (d) 4)=((E1*11)-(F1*H1))/R1 (d) 5)=((E1*11)-(D1*T1))/R1 (d) 5)=((D1*H1)-(E1*G1))/R1 (d) 6(7)=(TX*DSIN(T3+ALP))*(L2/L3) (d) 6(3)=-(DSIN(T3+ALP)) (d) 10)=DCIS(T3+ALP) (d) 10)=DCIS(T3+ALP) (d) 11)=0.0 		
122 123 124 125 126 127 128 129 130 131 132 133 134 155	<pre>().) 66 1=1,24 ().6 A(1)=R(1) C = *[HE FORCE TRANSFEW MATRIX C B(1)=DCOS(T3+ALP) B(2)=-DSIN(T3+ALP) B(2)=-DSIN(T3+ALP) B(3)=0.0 B(4)=((E1*L1)-(F1*H1))/R1 B(6)=((D1*H1)-(F1*H1))/R1 B(6)=((D1*H1)-(E1*G1))/R1 B(6)=((D1*H1)-(E1*G1))/R1 B(1)=DCOS(T3+ALP) B(11)=0.0 B(12)=((C1*H1)-(B1*T1))/R1</pre>		
122 123 124 125 126 127 128 129 130 131 132 133 134 125 136	<pre>().) 66 1=1,24 65 A(1)=R(1) C = *IHE FORCE TRANSFEW MATRIX C B(1)=DCOS(T3+ALP) B(2)=-OSIN(T3+ALP) B(2)=-OSIN(T3+ALP) B(3)=0.0 D(4)=((E1*L1)-(F1*H1))/R1 B(5)=((E1*L1)-(F1*H1))/R1 B(6)=((D1*H1)-(E1*G1))/R1 B(1)=OO B(1)=OO B(12)=((C1*H1)-(B1*I1))/R1 B(13)=((A1*I1)-(C1*G1))/R1</pre>		
122 123 124 125 126 127 128 129 130 131 132 133 134 126 136 137	(b) $366 1=1,24$ (c) $A(1)=R(1)$ C C *THE FORCE TRANSFER MATRIX C B(1)=DCOS(T3+ALP) B(2)=-DSIN(T3+ALP) B(3)=0.0 B(4)=((E1*11)-(F1*H1))/R1 B(5)=((F1*G1)-(O1*T1))/R1 B(5)=((D1*H1)-(E1*G1))/R1 B(6)=((D1*H1)-(E1*G1))/R1 B(3)=(DSIN(T3+ALP)) * (L2/L3) B(3)=DSIN(T3+ALP) B(1)=DCOS(T3+ALP) B(11)=0.0 B(12)=((C1*H1)-(B1*T1))/R1 B(13)=((A1*T1)-(C1*G1))/R1		
122 123 124 125 126 127 128 129 130 131 132 133 134 155 136 137 138	0.) $66 = 1, 24$ 65 = A(1) = R(1) C F(1) = DCOS(T3+ALP) B(2) = -0SIN(T3+ALP) B(3) = 0.0 B(4) = ((E1*11) - (F1*H1))/R1 B(5) = ((F1*G1) - (01*T1))/R1 B(6) = ((D1*H1) - (E1*G1))/R1 B(6) = ((D1*H1) - (E1*G1))/R1 B(6) = -(DSIN(T3+ALP)) * (L2/L3) B(3) = -(DSIN(T3+ALP)) * (L2/L3) B(1) = 0.0 B(11) = 0.0 B(12) = ((C1*H1) - (B1*T1))/R1 B(13) = ((C1*H1) - (C1*G1))/R1 B(14) = ((B1*G1) - (A1*H1))/R1 B(15) = -(DCOS(T3+ALP)) * CTX* (L2/L3)		
122 123 124 125 126 128 129 130 131 132 136 136 137 138	0.) $66 \ I=1, 24$ $65 \ A(I)=R(I)$ C FINE FORCE TRANSFEW MATRIX C B(I)=DCOS(T3+ALP) B(2)=-DSIN(T3+ALP) B(2)=-DSIN(T3+ALP) B(3)=0.0 B(4)=((EI*II)-(FI*HI))/RI B(5)=((DI*HI)-(EI*GI))/RI B(6)=((DI*HI)-(EI*GI))/RI B(6)=-(DSIN(T3+ALP))*(L2/L3) B(3)=-(DSIN(T3+ALP)) B(10)=DCOS(T3+ALP) B(11)=0.0 B(12)=((CI*HI)-(BI*II))/RI B(13)=((A1*II)-(C1*GI))/RI B(14)=((B1*GI)-(A1*HI))/RI B(15)=-(DCOS(T3+ALP))*CTX*(L2/L3) B(16)=DCOS(T3+ALP))*CTX*(L2/L3)		
122 123 124 125 126 127 128 129 130 131 132 133 134 125 136 137 138 139	0.) 66 I=1,24 65 A(I)=R(I) C FINE FORCE TRANSFEW MATRIX C B(I)=DCOS(T3+ALP) B(2)=-DSIN(T3+ALP) B(2)=-DSIN(T3+ALP) B(3)=0.0 B(4)=((E1*L1)-(F1*H1))/R1 B(6)=((D1*H1)-(E1*G1))/R1 B(6)=((D1*H1)-(E1*G1))/R1 B(6)=((D1*H1)-(E1*G1))/R1 B(1)=0.0 B(1)=0.0 B(1)=0.0 B(1)=0.0 B(1)=((C1*H1)-(B1*I1))/R1 B(13)=((A1*I1)-(C1*G1))/R1 B(14)=((B1*G1)-(A1*H1))/R1 B(15)=-(DCOS(T3+ALP))*CTX*(L2/L3) B(16)=DCOS(T3+ALP)+L2 B(17)=0.0		
122 123 124 125 126 127 128 129 131 132 133 134 135 136 137 138 139 141	0.) $66 \ i=1,24$ $65 \ A(1)=R(1)$ C *IHE FORCE TRANSFEW MATRIX C $B(1)=DCOS(T3+ALP)B(2)=-0SIN(T3+ALP)B(3)=0.0B(4)=((E1*I1)-(F1*H1))/R1B(5)=((F1*G1)-(D1*I1))/R1B(6)=((D1*H1)-(E1*G1))/R1B(6)=((D1*H1)-(E1*G1))/R1B(3)=(DSIN(T3+ALP))*(L2/L3)B(3)=-(DSIN(T3+ALP))B(11)=0.0B(12)=((C1*H1)-(B1*I1))/R1B(13)=((A1*I1)-(C1*G1))/R1B(13)=((B1*G1)-(A1*H1))/R1B(15)=-(DCOS(T3+ALP))*CTX*(L2/L3)B(16)=DCOS(T3+ALP)*L2B(17)=0.0$		
122 123 124 125 126 126 127 128 129 130 131 132 134 135 136 137 138 140 140	<pre>().) 66 1=1,24 ()5 A(1)=R(1) C C *[HE FORCE TRANSFEW MATRIX C B(1)=DCOS(T3+ALP) B(2)=-DSIN(T3+ALP) B(3)=0.0 D(4)=((E1*11)-(F1*H1))/R1 B(5)=((F1*G1)-(D1*T1))/R1 B(6)=((D1*H1)-(E1*G1))/R1 B(6)=((D1*H1)-(E1*G1))/R1 B(3)=-(DSIN(T3+ALP))*(L2/L3) B(3)=-(DSIN(T3+ALP)) B(11)=0.0 B(12)=((C1*H1)-(B1*T1))/R1 B(13)=((D1*G1)-(A1*H1))/R1 B(13)=((D1*G1)-(A1*H1))/R1 B(14)=((B1*G1)-(A1*H1))/R1 B(15)=-(DCOS(T3+ALP))*(CTX*(L2/L3)) B(16)=DCOS(T3+ALP)+L2 H(17)=0.0 B(18)=0.0</pre>		
122 123 124 125 126 127 128 129 130 131 132 133 134 125 136 137 138 139 140 141 142	0.) $66 = 1, 24$ 65 = A(1) = R(1) C F(1) = DCOS(T3+ALP) B(2) = -DSIN(T3+ALP) B(3) = 0.0 B(4) = ((E1 + 11) - (F1 + H1))/R1 B(5) = ((D1 + H1) - (F1 + H1))/R1 B(6) = ((D1 + H1) - (E1 + G1))/R1 B(6) = ((D1 + H1) - (E1 + G1))/R1 B(6) = -(DSIN(T3 + ALP)) + (L2/L3) B(3) = -(DSIN(T3 + ALP)) + (L2/L3) B(3) = -(DSIN(T3 + ALP)) + (L2/L3) B(3) = -(DSIN(T3 + ALP)) + (L2/L3) B(1) = DSIN(T3 + ALP) B(1) = DSIN(T3 + ALP) B(1) = DSIN(T3 + ALP) B(1) = ((C1 + H1) - (B1 + T1))/R1 B(13) = ((A1 + T1) - (C1 + G1))/R1 B(14) = ((B1 + G1) - (A1 + H1))/R1 B(15) = -(DCOS(T3 + ALP)) + (C2 + L3) B(16) = DCOS(T3 + ALP) + (2 B(17) = 0.0 B(18) = 0.0 B(19) = 1.0		
122 123 124 125 126 127 128 130 131 132 134 135 136 137 138 139 140 141 142 143	(b) 66 1=1,24 65 A(1)=R(1) C F(1)=DCOS(T3+ALP) B(2)=-DSIN(T3+ALP) B(2)=-DSIN(T3+ALP) B(3)=0.0 B(4)=((E1*L1)-(F1*H1))/R1 B(5)=((F1*G1)-(D1*T1))/R1 B(6)=((D1*H1)-(E1*G1))/R1 B(6)=((D1*H1)-(E1*G1))/R1 B(7)=UTX*DSIN(T3+ALP) B(10)=DU(DS(T3+ALP))*U2 B(9)=DSIN(T3+ALP) B(11)=0.0 B(12)=((C1*H1)-(B1*T1))/R1 B(13)=((A1*T1)-(C1*G1))/R1 B(14)=((B1*G1)-(A1*H1))/R1 B(15)=-(DCOS(T3+ALP))*CTX*(L2/L3) B(16)=DCUS(T3+ALP) %U2 B(17)=0.0 B(18)=0.0 B(18)=0.0 B(19)=1.0 B(20)=((B1*F1)-(C1*E1))/R1 F(11)=-(A1*E1)/R1 F(11		
$\begin{array}{c} 122\\ 123\\ 125\\ 126\\ 126\\ 127\\ 1289\\ 131\\ 132\\ 133\\ 136\\ 137\\ 138\\ 139\\ 141\\ 142\\ 1443\\ 1445\\ 14$	0.) 66 $1=1,24$ 65 $A(1)=R(1)CF(1)=DCOS(T3+ALP)B(2)=-DSIN(T3+ALP)B(2)=-DSIN(T3+ALP)B(3)=0.0B(4)=((E1*11)-(F1*H1))/R1B(5)=((F1*G1)-(D1*T1))/R1B(6)=((D1*H1)-(E1*G1))/R1B(6)=((D1*H1)-(E1*G1))/R1B(6)=-(DSIN(T3+ALP))*(L2/L3)B(3)=-(DSIN(T3+ALP))B(11)=0.0B(11)=0.0B(12)=((C1*H1)-(B1*T1))/R1B(13)=((A1*T1)-(C1*G1))/R1B(15)=-(DCUS(T3+ALP))*CTX*(L2/L3)B(16)=DCUS(T3+ALP))*CTX*(L2/L3)B(16)=DCUS(T3+ALP))*CTX*(L2/L3)B(16)=DCUS(T3+ALP))*CTX*(L2/L3)B(16)=DCUS(T3+ALP)+(L2)B(17)=0.0B(18)=0.0B(19)=1.0B(20)=((B1*F1)-(C1*E1))/R1B(21)-((C1*U1)-(A1*F1))/R1$		
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	0.) 66 $1=1, 24$ 65 $A(1)=R(1)CFINE FORCE TRANSFEW MATRIXCB(1)=DCOS(T3+ALP)B(2)=-DSIN(T3+ALP)B(3)=0.0B(4)=((E1*11)-(F1*H1))/R1B(5)=((F1*G1)-(O1*T1))/R1B(6)=((D1*H1)-(E1*G1))/R1B(6)=((D1*H1)-(E1*G1))/R1B(1)=0.0B(1)=DCOS(T3+ALP)B(1)=0.0B(1)=(C1*H1)-(B1*T1))/R1B(14)=((B1*G1)-(A1*H1))/R1B(15)=-(DCOS(T3+ALP))*CTX*(L2/L3)B(16)=DCOS(T3+ALP))*CTX*(L2/L3)B(16)=DCOS(T3+ALP))*CTX*(L2/L3)B(16)=DCOS(T3+ALP))*CTX*(L2/L3)B(16)=DCOS(T3+ALP))*CTX*(L2/L3)B(16)=DCOS(T3+ALP)+L2B(17)=0.0B(18)=0.0B(19)=1.0B(20)=((B1*F1)-(C1*E1))/R1B(22)=((A1*L1)-(S1*O1))/R1$		
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	<pre>0.) 66 1=1,24 65 A(1)=R(1) C = *[HE F0KCE TRANSFEW MATRIX C B(1)=DCOS(T3+ALP) B(2)==DSIN(T3+ALP) B(2)==DSIN(T3+ALP) B(3)=0.0 B(4)=((E1*11)-(F1*H1))/R1 B(6)=((D1*H1)-(F1*H1))/R1 B(6)=((D1*H1)-(F1*G1))/R1 B(6)=((D1*H1)-(F1*G1))/R1 B(1)=CTX*DSIN(T3+ALP) B(11)=0.0 B(12)=((C1*H1)-(B1*T1))/R1 B(13)=((A1*T1)-(C1*G1))/R1 B(13)=((A1*T1)-(C1*G1))/R1 B(15)=-(DCOS(T3+ALP))*CTX*(L2/L3) B(16)=DCOS(T3+ALP))*CTX*(L2/L3) B(16)=DCOS(T3+ALP))*CTX*(L2/L3) B(16)=DCOS(T3+ALP))*CTX*(L2/L3) B(16)=DCOS(T3+ALP)+C2 H(17)=0.0 B(18)=0.0 B(18)=0.0 B(18)=0.0 B(19)=1.0 B(20)=((B1*F1)-(C1*E1))/R1 B(22)=((A1*F1)-(51*D1))/R1 B(23)=-CTX/L3</pre>		
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	0.) 66 $1=1, 24$ 65 $A(1)=R(1)CF(1)=DCOS(T3+ALP)B(2)=-0$ SIN(T3+ALP) B(2)=-0 SIN(T3+ALP) B(3)=0.0 B(4)=((E1*11)-(F1*H1))/R1 B(5)=((F1*G1)-(01*11))/R1 B(6)=((D1*H1)-(E1*G1))/R1 B(6)=((D1*H1)-(E1*G1))/R1 B(6)=(DSIN(T3+ALP)) * (L2/L3) B(3)=-(DSIN(T3+ALP)) * (L2/L3) B(3)=-(DSIN(T3+ALP)) * (L2/L3) B(10)=DSIN(T3+ALP) B(10)=DSIN(T3+ALP) B(11)=0.0 B(12)=((C1*H1)-(B1*I1))/R1 B(13)=((A1*I1)-(C1*G1))/R1 B(14)=((B1*G1)-(A1*H1))/R1 B(16)=DCOS(T3+ALP) * (L2/L3) B(16)=DCOS(T3+ALP) * (L2/L3) B(16)=DCOS(T3+ALP) * (L2/L3) B(16)=DCOS(T3+ALP) * (L2/L3) B(16)=DCOS(T3+ALP) * (L2/L3) B(16)=DCOS(T3+ALP) + (L2) B(17)=0.0 B(18)=0.0 B(19)=1.0 B(20)=((B1*F1)-(C1*E1))/R1 B(21)=((C1*01)-(A1*F1))/R1 B(23)=-CTX/L3 J(24)=1.0		
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	0.) 66 $1=1,24$ 65 $A(1)=R(1)CFIHE FORCE TRANSFEW MATRIXCB(1)=DCOS(T3+ALP)B(2)=-0SIN(T3+ALP)B(3)=0.0B(4)=((E1*11)-(F1*H1))/R1B(5)=((F1*G1)-(O1*I1))/R1B(5)=((D1*H1)-(E1*G1))/R1B(6)=((D1*H1)-(E1*G1))/R1B(3)=-(DSIN(T3+ALP)) * (L2/L3)B(3)=-(DSIN(T3+ALP)) * (L2/L3)B(1)=0.0B(1)=0.0B(1)=0.0B(1)=0.0B(1)=0.0B(1)=((C1*H1)-(B1*I1))/R1B(13)=((A1*I1)-(C1*G1))/R1B(16)=DCOS(T3+ALP)) * CTX*(L2/L3)B(16)=DCOS(T3+ALP) * L2B(17)=0.0B(18)=0.0B(19)=1.0B(20)=((B1*F1)-(C1*E1))/R1B(22)=((A1*F1)-(G1*O1))/R1B(23)=-CTX/L3A(24)=1.0N=3$		

150		M5A-0
151		M5-15=0
152		L -
155		CALL MPRD(A, B, R, N, M, MSA, MSB, L)
154		Di1 // 1=1,9
155	11	A(1) #R(1) .
156		H(L)=XPF
157		3(2)=YPF
150		o(3) 0.0
155		N= 3
160		<u>ز</u> = M
101		∽15A =∪
16.2		A, H=()
103		$1 \neq 1$ (1)
164		CALL MPRD(A.B.K.N.M.MSA.MSB.L)
165		X (= R(1)
160		YY=R(2)
167		R = R (3)
1tes		IT(P2.F0.360.0) 60/10/999 11
109		WRIH (6,200) P2,XX,YY,RT
170	200	FURMAT(1H0,5X,F12.6,8X,F12.0,8X,F12.0,8X,F12.6)
1.71		GC 10 5
110	499	STUP
113		END

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\$ JUB TIME = 20, NUSUBCHK С **** C С CASE 1 C * ¢ C C άt. Ċ ** ***** K.E.D. ANALYSIS UF C C. _ _ _ ____ THE CUGNATE MECHANISM OF THE SOURCE FOUR-BAR LINKAGE С -----C C С **** **** C ۱. * THE LINK LENGTHS OF THE COGNATE MECHANISM IS CUMPUTED JSING *THE PRUPERTY FROM THE CALEY'S DIAGRAM AND DISPLAYED AS FOLLOWS:-С *CLI---- THE INPUT-LINK OF THE COGNATE MECHANISM IN INCHES. *UL2---- THE COUPLER EXTENDER LENGTH IN INCHES. C C. *CL3---- THE COUPLER LINK LENGTH OF CUGNATE IN INCHES. С *CL4---- THE FULLOWER LENGTH OF THE CUGNATE IN INCHES. *CL5---- THE GROUND LINK LENGTH DF THE CUGNATE IN INCHES. C C С C *NUTE: C ¥ ----C. *THE COGNATE MECHANISM IS A CROSSED FOUR-BAR LINKAGE. C *----C. *CALP---- THE KIGID ANGLE IN RAD. BETWEEN COUPLER AND EXTENDER. С *COM2---- THE ANGULAR VELOCITY OF THE INPUT-LINK RAD/SEC. *COM3---- THE ANGULAR VELOCITY OF THE COUPLER LINK RAD/SEC. L Ċ *COM4---- THE ANGULAR VELOCITY OF THE FOLLOWER LINK C *CALPH2---- THE ANGULAR ACC. OF THE INPUT LINK IS ZERD. *CALPH3---- THE ANGULAR ACC. OF THE COUPLER RAD/SEC/SEC. C C Ċ *CALPH4---- THE ANGULAR ACC. OF THE FOLLOWER IN RAD/SEC/SEC. C. THE FOLLOWING INFORMATION IS REQUIRED FOR THE PROGRAM: C C Ċ *THE LINK LENGTHS OF THE SOURCE FOUR-BAR (L1,L2,L3,L4,L5) AND *THE RIGID ANGLE ALP ASSOCIATED WITH THE COUPLER AND EXTENDER OF С *THE SOURCE LINKAGE AND THE INPUT LINK VELOCITY. C C. **** C DOUBLE PRECISION L1, CL1, L2, CL2, L3, CL3, L4, CL4, L5, CL5, K1, CK1, K2, CK2, *K3,CK3,K4,CK4,K5,CK5,AA,CAA,BB,CBB,CC,CCC,DD,CDD,EE,CEE,FF,CFF,T2, * F \$ + C T 3 + F 4 + C T 4 + UM2 + C UM2 + DM3 + C UM3 + OM4 + C UM4 + A J + C A J + B J + C B J + C J + C C J + D J + C *UJ, FJ, CEJ, FJ, CFJ, ALP, CALP, ALPH2, CALPH2, ALPH3, CALPH3, ALPH4, CALPH4, D *CUS, DSIN, DATAN, DSJRT, DCOT, CX, CCX, SX, CSX, CTX, CCTX, A1, CA1, B1, CB1, C1, *CC1, 01, CD1, E1, CE1, F1, CF1, G1, CG1, H1, CH1, I1, CI1, R1, CR1, P1, CA, CCA, M1, *CMI, ME, CME, XP, CXP, YP, CYP, XX, CXX, YY, CYY, NXP, NCXP, NYP, NCYP *, XPP, YPP, BETA, Z1, Z2, K, CBTA, SBTA, TBTA *, DU XX, RUXX, TUPPX, TUPPY *• S DIMENSION A(64), B(64), R(64), U(64), F(64) L1=10:0 L2 = 10.013=30.0 L4=25.0 1.5=30.0 K1 = 15 / E1

1

23

4

5

6

7

8

9		K2=L5/L4
10		K3=(L1*L1-L3*L3+L4*L5 *L5)/(2 .0*L1*L4)
11		K4=L5/L3
12		K 5= (L 4*L 4-L 5*L 5-L 1*L 1-L 3*L 3) /(2.0*L 1* L 3)
13		P1=3.142857143
	С	
	C	S THE SPEED OF ROTATION OF THE INPUT LINK =300 R.P.M.
• /	C	
14		
15		
16		WRITE(6,100)
11		*01 DE DIN
10		
10		$F_{2} = -10.0$
20		$f_2 = (10 + 2) - (3 + 0 + 1) / (3 + 0)$
21		A = DC OS (T2) + K3 - K1 - (K2 + DC OS (T2))
22		$BB = -2.0 \pm 0.05 IN(12)$
23		$C(= K1 + K3 - (1 \cdot 0 + K2) * DCOS(T2)$
24		DU = (K4*UCOS(T2)) + DCOS(T2) + K5 - K1
25		EE = -2.0 * DS IN(I2)
26		FF=(K4*DCOS(T2))-DCOS(T2)+K5+K1
27		13=2。U*(DATAN((-EE-USQRT(EE*EE-4。0*DD*FF))/(2。0*DD)))
28		T4=2.0*(DATAN((-BB-DSQRT(BB*BB-4.0*AA*CC))/(2.0*AA)))
29		ALP = PI/3.0
30		XP=(L1*DCOS(T2))+(L2*DCOS(ALP+T3))
31		YP=(L1*DSIN(T2))+(L2*DSIN(ALP+T3))
	С	*THE COUPLER CUGNATE DIMENSIONS ARE AS FOLLOWS:- *
	С	
32		K= L 2/L 3
22		CL4=DSQR1(112*L2)+L3*L3)-(2.0*L2*L3*DCUS(ALP)))
14		LL 3=L 4%LL 4/L 3 CL 3=K#L 4
35		ししてきべきしゃ とことに、いのサイノ リンチン そうチャンシンブリ たやした シーノン・ウォレ たまに たんどまいたい たくてい ひろうろ
30		LL 3=USWRILL(R*L3)**21*(L3+L3+L3)=(2*U*L3+L3+L3+L5+L*UCUSTAL*///)
38		GE 1→E 1 * GE * 7 E 3 C KT A= (1 3 k 1 3) + ((1 4 k C 1 4) − (1 2 k 1 2)) / (2 . () k 1 3 k C 1 4)
30		SAT A= 0 SORT (1 - 0 - (CATA) + 2)
40		
41		B_1 T $A = DATAN (TBTA)$
42		CAI P = PI - (BE TA + AI P)
43		CK 1=CL 5/CL 1
44		CK2 = -CL5/CL4
45		CK3=(CL3*CL3-CL1*CL1-CL4*CL4-CL5*CL5)/(2.0*CL1*CL4)
46		CK 4 = - CL 5/CL 3
47		CK5=(CL1*CL1+CL3*CL3+CL5*CL5-CL4*CL4)/(2.0*CL1*CL3)
48		CAA=UCOS(T2)+CK3-CK1-(CK2+DCOS(T2))
49		$CBB = -2.0 \neq DSIN(T2)$
50		$CCC = CK1 + CK3 - (1 \cdot 0 + CK2) + DCOS (T2)$
51		$C_{0}D = (CK4*DCUS(T2)) + DCUS(T2) + CK5 - CK1$
52		
53		$CFF = \{CK4 \neq DCUS(12)\} - DCUS(12)\} + CK5 + CK1$
54		UI 3=2.04(UAIAN((-UEE*)SQK)(UEE*UEE*-4.04(U)*UFF])/(2.04(U))) (14-2.04(DAIAN((-UEE*)SQK)(UEE*UEE*-4.04(D)))
35 54		UI 4 − 2 + U 4 UAI ANI (* UDE = USQKI (UDE * UDE * 4 U* UAA* 5 US / / (2 + U* UAA))) VOE / () + UE OS / TON 1 + / EI 2 + DE COS (DE = / C + D = CTO + D)
50		
57	c	TEFTUELTUSING LATITUELTUSING FTUENDUT LINK OF THE COCNATE
5.0	C	(IM)24 - THE ANOLEAN VECCUTT OF THE INFUT LINK OF THE CUGNATE.
50		(ALPH2=0.0
60		CUM3=(CL1+CUM2+US1NLT2-CT4))/(CL3+DS1N(CT3-CT4))
61		COM 4 = (C + 1 + C - 0 + 2 + 1) + (C + 3 + 7 + 2) + (C + 4 + 0 + 1) + (C + 1) + (C + 4 + 0 + 1) + (C +

62		CAJ=CL4+DSIN(CT4)	
63		CBJ=CL3+DSIN(CT3)	
64		CCJ =- (CL1*CALPH2*DSIN(T2)) - (CL1*COM2*CO	M2*DCOS(T2))+(CL3*COM3*COM3

65		(0) = (1 + 4) (0) (1 + 4) (0) (1 + 4) (0) (1 + 4) (0) (1 + 4) (0) (1 + 4) (0) (1 + 4) (0) (1 + 4) (1	
66			· · · · · ·
00.			
01			M2*USIN11211-1013+00M3+00M3
		**USIN((13))+(CL4*CUM4*CUM4*DSIN(C14))	
68		CALPH3=(CCJ*CDJ+CAJ*CFJ)/(CAJ*CEJ-CBJ*C	
69		CAL PH4= (CC J*CE J~CB J*CF J) / (CAJ*CEJ~CBJ *C	DJ)
70		LXP A=-(CL1*CUM2*CUM2*DCUS(T2))-(CL1*C AL	PH2*DSIN(T2))+(CL2*COM3*COM
		*3*DCUS(CALP-CT3))-(CL2*CALPH3*DSIN(CALP	-CT31)
71		CYPA=-(CLI*COM2*COM2*DSIN(T2))+(CLI*CAL	PH2*DCOS(T2))-(LL2*COM3*COM
		*3*DSIN(CALP-CT3))-(CL2*CALPH3*DCOS(CALP	-([3])
72		CXPE=CXPA*2_0/(12,0*32,178)	
73		$(VDE \sim (VOA \pm 2 - 0) (12 - 0 \pm 32 - 178)$	
7.		$C \Lambda I = D(C) S (T 2)$	
74			
15		CBL=USIN(12)	
16		LLI=DLUS(L14)	
11		CD1 = -DSIN(T2)	
78		CE1 = -DCOS(T2)	
79		CF1=DSIN(CT4)	
80		CG1=(CL2*DCOS(T2)*DSIN(CALP-CT3))+(CL2*	DSIN(T2)*DCUS(CALP-CT3))
81		CH1=(CL2*DCOS(T2)*DCOS(CALP-CT3))-(CL2*	DSIN(T2) * DSIN(CALP-CT3))
82		C11=(CL2*DCOS(T2)*DSIN(CALP-CT3))+(CL3*	DCOS(CT3)*DCOS(CT4))+(CL2*D
		*SIN(CT4)*DCOS(CALP-CT3))+(CL3*DSIN(CT4)	*DSIN(CT3))
83		LR1 = (LA1 + ((CE1 + CI1) - ((E1 + CH1))) - (CB1 + (CH1)))	CD1 + C11) - (CF1 + CG1)))+ (CC1 + (
.		*((D)*(H))=((F)*(G1)))	
54			
04			
85			
86			
	C		
	C	THE FORCE-TRANSFORMATION MATRIX FOR THE	CUGNATE MECHANISM.
	C		
87		U(1)=-DCUS(CALP-CT3)	
88		U(2)=-DSIN(CALP-CT3)	
89		U(3)=0.0	
90		U(4)=((CE1*CI1)-(CE1*CH1))/CR1	
91		U(5) = ((CF1 * CG1) - (CD1 * CI1))/CR1	
92		U(6) = ((C0) * CH1) + (CE) * CG1)) / CB1	1
02		$H(7) = -(1 + 2\pm)(5 + M(1) + 10 + 10 + 10 + 10 + 10 + 10 + 10 + $	
~ ~			
94		(10) - (12 + 0) (10) (10) = (10)	
99			
96		U(10) = -U(US(CALP - UT3))	
97		0(11)≠0.0	
98		U(12) = ((CC1*CH1) - (CB1*C11))/CR1	
99		U(13)=((CA1+C11)-(CC1+C31))/CR1	
100		U(14)=((CH1*CG1)-(CA1*CH1))/CR1	
101		U(15) = -CL2*DCOS(CALP-CI3)*CCTX/CL3	
102		U(16)=-CL2*DCUS(CALP-CT3)	
103		$\cup(17)=0.0$	
104		(118) = 0.0	
105		U(19)=1.0	
106		(1(2()) = (1(B) *(F1) - (((1*(F1))/(B)	
107		11(21)~((()1±())1)_(()()1±(()1±())1)	
107			
108		リインマナネイイレム上半しに エナーイレジ エキレジエナナノルド エー・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・	
109		U(23) = CCTX/CL3	
110		U(24) = 1.0	
	C		
	C	TRANSPUSING THE FORCE-TRANSFER MATRX	

	C TRANSPOSING THE FURCE TRANSFER MATRIX (CBETA) OF THE COGNATE.
111	C Ni≠ Ω
112	N= 0
113	CALL GMTRA(U,R,N,M)
	C THE TRANSPOSED FORCE-TRANSFER MATRIX IS MULTIPLIED BY THE C COGNATE FLEXIBILITY MATRIX .
114	100 88 1=1.24
115	88 A(1)=R(I)
	C *ALL LINKS ARE OF UNIFORM CROSS-SECTION OF DIA.≖0.5".
	C *''CCA''-CROSS-SECTIONAL AREA OF ALL LINKS.
116	CCA=0.1963495408
117	C **'CME''-YDUNG'S MUDULUS OF ELASTICITY FUR MATERIAL ALUMUNIUM.
	C
	C *''CMI''-CRUSS-SECTIONAL MOMENT OF INERTIA.
118	CNI = 0.0030079615
	C THE FLEXIBILITY MATRIX FOR THE COGNATE MECHANISM ""CF"".
119	E(1)=CL2/(CCΔ*CME)
120	F(2)=0.0
121	F (3)=F (2)
122	F(4)=F(2)
123	F(5) = F(2)
124	F(0)=F(2) F(7)=F(2) 2
125	F(8) = F(2)
127	F(9)=F(2)
128	F(10)=(CL2*CL2*CL2)/(3.0*CME*CMI)
129	F(11)=(CL2*CL2)/(2.0*CME*CMI)
130	F(12) = F(2)
131	F(13)=F(2)
133	F(15) ≠F(2)
134	F(16) = F(2)
135	F(17)=F(2)
136	F(18)=(CL2*CL2)/(2.0*CNE*CMI)
137	F(19)=CL2/(CME*CMI)
130	F(2))=F(2) F(2))=F(2)
140	F(22) = F(2)
141	F(23)=F(2)
142	F(24)=F(2)
143	F(25) = F(2)
144	F(26) = F(2)
145	F(28)=C1/(CCA*CME)
147	F(29) = F(2)
148	F(30)=F(2)
149	F(31)=F(2)
150	F (32) = F (2)
151	F(34)=F(2) F(34)=F(2)
153	F(35)=F(2)

154			F(36)=F(2)
155			F(37)=(CL1*CL1*CL1)/(3.0*CCA*CME)
156			F(38)=F(2)
157			F(39) = F(2)
158			F(40) = F(2)
159			F(41) = F(2)
160			F(42) = F(2)
161			F(43)=F(2)
162			F(44)=F(2)
163			F(45)=F(2)
164			F(46)=CL4/(CCA*CME)
165			F(47)=F(2)
166			F(48)=F(2)
167			F(49)=F(2)
168			F(50) = F(2)
169			F(51) = F(2)
170			F(52) = F(2)
171			F(53) = F(2)
177			F(54) = F(2)
173			F(55)=CL3/(CCA*CME)
174			F(56) = F(2)
175			F(57) = F(2)
176			F(5B) = F(2)
177			F(59) = F(2)
178			F(60) = F(2)
179			F(61) = F(2)
180			F(62) = F(2)
181			F(63)=F(2)
1.62			F(64)=(13//3_0±CME±CM[)
102			
10.			M-0
185			
186			
187			1=8
188			(ALL MPRD(A.F.R.N.M.MSA.MSB.L)
	C		
	ĩ		THE PRODUCT & IS MUNITIPLIED BY THE EDRCE-TRANSFER MATRIX.
	č		
189	Ч,		DO 99 1=1-24
190		90	$\Lambda(1)=R(1)$
191		.,	H(1) = H(0) (CA) P - (T3)
102			H(2) = -DSIN(CALP - (T3))
103			
194			U(4)=((CE)*C[1)~((E)*CH1))/CR1
195			U(5) = ((CE) * CG1) - (CD) * (T1)) / (CR)
196			H(6) = ((CD) + (CH)) - (CF) + (CG)) / (CR)
197			$U(7) = -(CL2 \times USIN(CALP-CL3)) \times CCTX/CL3$
198			$U(\mathbf{A}) = -(1 2 \mathbf{I}) \mathbf{I} \mathbf{I} \mathbf{I} (\mathbf{A} \mathbf{I} \mathbf{P} - \mathbf{C} \mathbf{I} \mathbf{A})$
199			U(9) = DSIN(CALP - CT3)
200			U(1,0) = -DC(0S(CA) P - CT3)
201			(11) = 0, 0
201			(1/2) = ((CC) * (H)) - (CB) * (C(1))/(CB)
201			U(1,3) = ((CA) + (CC) + (CC) + (CG)) / (CR)
204			((14) = ((CB) * CG)) - (CA) * (CH)) / (CR)
205			$U(15) = -C(2 \times DCUS(C \Delta (P - CT3) \times CCTX/C(3)))$
204			$ (1 \land) = -(1 2 * D(OS)(C \land P - (T3))$
200			$ (17) \pm 0.0$
208			U(18)=0.0
200			$((19) \pm 1.0$
209			U(20)-((CR)*CE))-((C)*CE))/CP1
210			UIEUI-IIUDITUTIIIIUUITUCIIIIUUI

U(21)=((CC1*CD1)+(CA1*CF1))/CR1 211 U(22)=((CA1*CE1)-(CB1*CD1))/CR1 212 213 U(23)=CCTX/CL3 214 U(24)=1.0 215 N= 3 216 M=8 217 MSA=0 218 M5B=0 219 L=3 CALL MPRD(A,U,R,N,M,MSA,MSB,L) 220 221 UJ 111 1=1,9 222 111 A(I) = R(I)C THE PRODUCT IS MULTIPLIED BY THE EXTERNAL FORCE MATRIX ""P". 0 0 223 B(1)=CXPF22.4 B(2)=CYPF 225 B(3)=0.0 226 N = 3221 M = 1MSA=0 228 229 MS B =0 230 L = 1 231 CALL MPRD(A, B, R, N, M, MSA, MSB, L) 232 CXX =R(1) 233 CYY = R(2)CRT = R(3)234 С THE FULLOWING TRANSFORMATION LOCATES С ------С С С THE COGNATE IN ITS TRUE C C --- ----- -- ---С POSITION С _____ С 235 XOP=XPP-CL5 XRP=(XUP*DCOS(-BETA))-(YPP*DSIN(-BETA)) 236 CXP=XRP+L5 237 LYP=(XDP*DSIN(-BETA))+(YPP*DCUS(+BETA)) 238 239 NCX P=CXP+CXX 240 NCY P=CYP+CYY NC XP=C XP+C XX 241 NCY P=CYP+CYY 242 243 WRITE (6,200) P2, CXX, CYY, CRT 244 200 FURMAT(1HU, 5X, F12.6, 8X, F12.6, 8X, F12.6, 8X, F12.6) 245 1F(P2.6T.360.0) GO TO 1 246 60 TO 5 1 STOP 247 248 END SENTRY

APPENDIX C

CASE II: MASS AT EACH JOINT

\$JOB TIME=55,NOSUBCHK,LIBLIST Ú. L. ****** n'r ÷ ί C, LASE II * ¢ Ì. 4 * --------C t C Ĉ. * ± C * FACH ELEMENT HAS A CONCENTRATED MASS LOCATED AT EACH JOINT. * С, z. * Ŭ C. C 1 DOUBLE PRECISION L1+L2+L3+L4+L5+K1+K2+K3+K4+K5+DC0S+DSIN+DATAN+ *AA, BB, CC, DD, EE, FF, A1, B1, C1, D1, E1, F1, G1, H1, F1, CX, SX, CTX, DSQRT, * 12 • 13 • 14 • ALP • CA • M1 • ME • OM2 • OM3 • OM4 • AJ • BJ • CJ • DJ • EJ • FJ • ALP H2 • ALP H3 • *ALPH4, DCUT, P1, XP, YP, XX, YY, NXP, NYP *, ONTY, VOL1, VOL2, VOL3, VOL4, XAA, XBA, YAA, YBA, M1, M2, M3, M4 2 DIMENSION A(6+),0(64),R(64),S(37,2),Q(37,2) 11=10.0 3 4 L2=10.0 13= 30.0 5 L4=25.0 6 7 15=30.0 K1=15/11 н 9 K2=L5/L4 10 $K_3 = (L_1 \times L_1 - L_3 \times L_3 + L_4 \times L_4 + L_5 \times L_5) / (2.0 \times L_1 \times L_4)$ 11 K4=15713 12 K5= (L4*L4-L5*L5-L1*L1-L3*L3)/(2.0*L1*L3) 13 P1=3.142857143 Ċ SPEED ---- THE SPEED OF THE INPUT LINK IN R.P.M. С C 14 SPEEJ=300.0 15 UM2=(2.0*PI*SPEED)/60.0 WRITE(6,100) 16 100 FORMAT(1H1,9X, DEGREES', 13X, 'X-DISP.DF P', 3X, 'Y-DISP.DF P', 10X, 'Z-17 *KJT.JF P!) 1.8 P2 = -10.0 19 5 P2=P2+10.0 $12 = (P2 \times 2 \cdot 0 \times P1) / (360 \cdot 0)$ 20 AA = UCOS(T2) + K3 - K1 - (K2 * DCUS(T2))21 $BB = -2.0 \times DSIN(T2)$ 22 23 CC = KI + K3 - (1.0 + K2) + UCUS(T2)24 00 = (K4*0CUS(T2))+0CUS(T2)+K5-K1 25 ++=-2.0*DS1N(12) 26 Ft = (K4 * DC OS(T2)) - DCOS(T2)+K5+K1 13=2.0*(DA1AN((-EE-DSQRT(EE*EE-4.0*DD*EE))/(2.0*DD))) 27 14=2.0*(DA1AN((-88-050RT(88*88-4.0*AA*CC))/(2.0*AA))) 28 29 CX = DC(1)S(14 - T3)30 SX-DSLN(14-13) 31 LTX=CX/SX 32 ALP=PI73.0 \mathbf{p}_{i} \mathbf{x} XP = (1 1#00 05(12)) + (1 2#0005(ALP+T3)) YP=((11*D5IN(12))+(L2*DSIN(ALP+T3)) 34 043=(L1*042*051N(14-13))/(L3*0SIN(13-T4)) 54, 36 1944=(L1*0M2*05IN(12-T3))/(L4*0S1N(T4-T3)) 21 AJ-L4*051N(T4) 38 0J=13*051N(13)

39		UJ=(L1*0M2*0M2*0C0S(T2))+(L3*0M3*0M3*0C0S(T3))-(L4*0M4*0M4*0C0S(T4	ł
		*))	
40			
41		τα πτο προτογιατιστιστιστ - το το το το μαλαματικό το το το ματά το μαρακατιστικό το μαρακά το μαρακά το μαρακά το μαρακά το μαρακά το μα	4
		())	·
43		AL P1(2=0-0	
44		$ALP113 = (CJ \neq JJ - AJ \neq FJ)/(AJ \neq FJ - BJ \neq DJ)$	
45		ALPH4=(LJ*FJ-BJ*FJ)/(AJ*EJ-BJ*DJ)	
46		XPA=-{L1*OM2*OM2*DCUS{T2}}-{L1*ALPH2*DSIN(T2}}-{L2*UM3*OM3*DCOS(
		☆ALP+T3))-(L2*ALPH3*DSIN(ALP+T3))	
41		YPA=(L1*ALPH2*DCUS(T2))-(L1*0M2*JM2*DS1N(T2))+(L2*ALPH3*DCUS(ALP+	
		[3])([2(M3*OM3*DSIN(ALP+F3))	
48		$XAA = \{1 \mid 2 \in SIN(12) \neq ALPH2\} - \{L \mid 2 \in SIN(2) \neq 0 \leq 2 \leq$	
49		YAAニ(L1*UUUS(12)*ALFHZ)=(L1*US1N112)*UHZ*UHZ) YAAニ(L1*UUUS(12)*ALFHZ)=(L1*US1N112)*UHZ*UHZ) YAAニ(L1*UUUS(12)*ALFHZ)=(L1*US1N12)*UHZ*UHZ)	2
50		ANA(LITALFNZ+USIN(127)-(LITOM2+0M2+0C03(127)-(LITOM2+0M3+0C03(12))	,
51		$Y_{1} = (1) + x_{1} + (1) + y_{1} + (1) $	3
		*)) + (L3*ALPH3*0CUS(T3))	
	C		
	C	★ALL LINKS ARE OF UNIFORM CIRCULAR CROSS-SECTION OF DIA.=3.5 IN. ★	:
	С		
	С	*"CA"-CRUSS-SECTIONAL AREA OF ALL LINKS.	r.
	¢,		
5.		CA= 0.1963495408	
	C C		
	C	*"ME"-YJUNGS MUDULUS OF ELASTICITY FUR THE MATAKIAL ALUMUNIUM• *	
1: 2	L,	ME = 10000000 0	
7.7	1	PF - 1000000.0	
	6	*"MI"-CRUSS-SECTIONAL MOMENT OF INFRIA. *	¢.
	č		
54		M1=0.0030674615	
	٢,		
	° C	DENSITY OF ALUMUNIIUM = 0.098.	
	C		
55			
56		(), = 32 + 178 ¥12 + J (), 1 + 2 + 4 + 3	
51		$\mathbf{V}(\mathbf{L}, \mathbf{L}) = (\mathbf{L}, \mathbf{V}, \mathbf{L}, \mathbf{L})$	
50			
60			
61		MI = DNTY * VUL I	
62		M2 > DN TY* V01 2	
63		M 3= UITY×VOL 3	
64		M4 = DNTY * V ()L4	
65		P1=(M2*XPA)/(32-178+12-0)	
66		Z2 = (M2 * YPA) / (32 - 176 * 12 - 0)	
67			
58 61		1947 (MIA) (AAAYDCUS) (Z) + 4 (A+DS) (NI (Z)) / (GC)	
20		$P_{1} = \{M_{2} \in \{V, N, K_{1}\} \mid X \in \{V, -1\}, N, K_{2} \in \{V, -1\}, N $	
71		$P \neq (M \Rightarrow (YAA \Rightarrow i) \land (N(TA) = XA \Rightarrow D(CUS(TA))) / G(C)$	
12		Pd= 0.0	
73		$A1 \neq DC \cup S(T2)$	
14		B1 = -DSIN(Tz)	
15		(1 = DL((5 (T4)	
14		01 = 0516(12)	
11		1=DC.15(T2)	
7 12		$E = OS I N (T \Delta)$	

79		G1=-(L2*0LUS(4LP+T3)*DC0S(T2))+(L2*0SIN(ALP+T3)*DC0S(T2))
80.		HL=-(1,2*DCUS(ALP+T3)*DCDS(T2))-(L2*DSIN(ALP+T3)*DSIN(T2))
81		11=DS1N([4)*((L2*DCOS(T3))-(L2*DCOS(ALP+T3))+DCUS([4)*((L2*DSIN(
		#ALP+T3)}-(L3+0S1N(T3))
82		Ri=(A1»(E1*I1-F1*H1))-(B1*(D1*I1-F1*G1))+(C1*(D1*H1-E1*G1))
	С.	THE FURCE TRANSFORMATION MATRIX.
83		A(1)=DCDS(T3+ALP)
84		A(2) = -OSIN(T3+ALP)
85		A(7)=0.0
86		A(4)=((F1+1)-(F1+H1))/R1
87		$A(5) = ((+1 \neq G1) = (D1 + I1))/R1$
88		A(6)=((D1+H1)-(E1+G1))/R1
89		A(7)=CFX*DSIN(T3+ALP)*(L2/L3)
90		A(8)=-(DSIN(13+ALP))*L2
91		$\Lambda(9) = DSIN(T3+ALP)$
92		A(10) = DCOS(T3+ALP)
93		A(11) -0.0
94		Λ(12)=((C1+H1-B 1+I1))/R1
95		$A(L_3) = ((AL + II) - (CL + GI))/RI$
96		$A(1 4) = ((B 1 \times G 1) - (A 1 \times H 1))/R1$
. 97		A(15):-(DCDS(13+ALP))*CTX*(L2/L3)
98		A(16)=DCUS(T3+ALP)*L2
99		$A(1) = 0 \cdot 0$
100		$\wedge (18) = 0 \cdot 0$
101		A(19) = 1.0
102		A(20)=((B1*F1)→(C1*E1))/R1
103		A(21) = ((C1 + D1) - (A1 + F1))/R1
104		A(22) = ((A1 + E1) - (B1 + D1))/R1
105		$A(23) = -(1X/L)^3$
106		A(24)=1.0
107		N = 8
198	<i>,</i> •	
100	U	ATRANSPUSING THE FIRLE TRANSFURMATION MATRIXUSETAL.
109	c	UALE OMIKALA (K (N) MI 1997 - DAHLONSEN ENSEL DANICECO, MATDIVILC, MHITTDILEN OV ELEVIQTITTV MATA
	(. (- PRANSEDSTO FORGE TRANSECK MATRIX IS POLIFIELD OF FERATOLETTE MATR-
110	٢,	(1) by L-1.2A
111		
	í.	THE FIFTHERE MATRIX (F)
112		5(1)=12/((A*MF))
111		(12) = 0 = 0
114		(3, (3,) = 0, 0)
115		(3 + 3) = 0
116		3(5) = 0
117		$H(\alpha) = 0 \cdot 0$
118		((1)) = (1, 0)
119		B(B)-0.0
1.20		N(9) = 0. 0
121		$\beta(10) = (12 \pm 12 \times 12) / (3 + 0 \times ME \pm MI)$
122		$(11) - (L2 \times L2) / (2.0 \times ME \times ME)$
123		3(12) = 0.0
124		8(13) 0.0
125		B(14) = ().()
126		
4.15.15		N(15)=0.0
127		0(15) = 0.0 B(16) = 0.0
127 128		B(15) = 0.0 B(16) = 0.0 B(17) = 0.0
127 128 129		o(15)=0.0 B(16)=0.0 B(17)=0.0 B(13)=(L2*L2)/(2.0≠ME*MI)
127 128 129 130		B(15)=0.0 B(16)=0.0 B(17)=0.0 B(13)=(L2*L2)/(2.0*ME*MI) B(19)=L2/(ME*MI)
127 128 129 130 131		0(15)=0.0 B(16)=0.0 S(17)=0.0 B(13)=(L2*L2)/(2.0*ME*MI) B(19)=L2/(ME*MI) B(20)=0.0
127 128 129 130 131 132		0(15)=0.0 B(16)=0.0 B(17)=0.0 B(13)=(L2*L2)/(2.0*ME*MI) B(19)=L2/(ME*MI) B(20)=0.0 B(21)=0.0

133		4(22) = 0.0			
134		3(23)=0.0			
135		B(24)=0.0			
136		8(25)=0.0			
137		B(26) = 0.0			
138		ls(27)=0.0			
139		$B(28) = (1/(CA \neq ME))$			
140		H(2y) = 0			
1.4.1					
14.2					
1.47		(1,1,2) = 0.0			
143		8(32) 0.0			
144		H(_33)=0.0			
145		H(34) = 0			
140		B(3,5)=().0			
147		8(36)≖0.0			
148		B(37)⇒(L1*L1*L1)/(3.U*CA*ME)			
149		8(38)=0.0			
150		8(39) =0.0			
151		u(40) = 0.0			
152		B(41)=0			
153		B(42)=0.0			
154		H(43)=0.0			
166		B(44)=0			
167		B(44)=0.0			
120					
157		B(46)=147(CA# Ht)			
155		B(47)=0.0			
159		8(48)=0.0			
160		8(49)=0.0			
161		8(50)=0.0			
162		B(51)=0.0			
163		B(52)=0.0			
164		6(53)=0.0			
165		8(54)=0.0			
166		B(55)≈L3/(CA≄ME)			
167		B(56)=0.0			
16.8		B(57) = 0.0			
16.0		8(58)=0.0			
170		B(59) = 0.0			
170					
171					
117		5(61)=0.0			
173		B(62) = 0.0			
174		8(63)=0			
175		B(64)=L3/(3.0*ML*MI)			
176		Not 3			
177		M# 3			
178		M5 A =0			
179		MSB =0			
180		L T B			
181		CALL MPRD(A.B.R.N.M.MSA.MSB.L)			
	C				
	č	* HU PRODUCT R IS MULTIPLIED BY THE	FORL	LRANSFER	HATRIX.
182	0	1) 1 66 1=1.24			
10.1		$A_{1} = A_{1} = A_{1$			
19.2		00 A(1) N(1)			
	, C	WIND CORE TRANSFER MATRIX			
	L	PITE FURCE IRANSFER MAIKER			
	L,				
184		3(1)=DCUS(13+ALP)			
185		B(2) = -DSIN(T3+ALP)			
186		(3) = (0, 0)			
187		B(4)-((El¥I1)-(E1¥H1))/R1			

¢:

	4151-111514	ki. 1 1	11 4 1 1 1 / 2 1	
Lan	01 37~11014	-017-0		
189	9(0)=(()1*	(HT)-(LI*GI)J/RL	
190	−6(7)=CTX*(SINCT	3+4LP)*(L2.	1631
.191	B(3) = -(0S)	IN (T3+	ALP)) #1 2	
100		1 4 4 4 4	0)	
174	0())-031N	I DEAL		
193	8(10)=0005	6113+A	LPJ -	
194	8(11)=0.0			
195	3(12) = ((C)	(*H1)-	$(B1 \neq (1))/R$	1
104	H(13)-11A1	*[1]-	1(1***1))/0	1
107	- D(1.))~((A)	****	((1+01)))/0	1
197	0114)=((8)	*611-	(AL*HIJJ/K	1
198	(15) =−(DC	JUS(T3	+ALP))*CTX	*(L2/L3)
199	a(16)=0009	5 (T 3 + A	LP)≄L2	
200	B(17) =0.0			
201	8(19)=0.0			
201	0(10)-0.0			
202	3(19)=1.0			
203	B(20)÷((B)	.*Fl)-	(L1*L1))/R	1
204	B(21)=((C)	*01)-	(A1*F1))/R	1
205	3(22)=((A)	*+11-	(B) *0111/8	1
2.37		/// 2		- .
200	0(2))-=017	V1. 5		
207	B(24)=1.0			
208	8(25)=8(3)			
209	0(26)=0(3)			
210	8(27)=3(3)			
111				
	01201-1-0			
515	3(29)=3(3)			
213	- 3(30) = 8(3)			
214	B(31)=B(3)			
215	B(32)=8141			
2.4.1				
210	0(20)=8(3)			
217	-B(34)+b(3)			
218	8(35)-8(3)	1		ř.
219	- らくろん) ニパくろう			
219	- B(36) ≠B(3) - U(32) +1 0		2 8 1	
219 220	H(36) ≠B(3) B(37) =1.0		1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 -	
219 220 221	B(36) ≠B(3) B(37) =1.0 B(38) ≠B(3)	•	μ.	
219 220 221 222	- B(36) ≠B(3) - B(37) =1.0 - B(38) ≠B(3) - B(39) =B(3)	•	4	
219 220 221 222 223	B(36) ≠8(3) B(37) =1.0 B(38) ≠B(3) B(39) ≠B(3) B(39) ≠B(3) B(40) ≈B(3)	•		
219 220 221 222 223 223 224	$B(30) + B(3) \\ B(37) + 1 = 0 \\ B(38) + B(3) \\ B(39) + B(3) \\ B(39) + B(3) \\ B(40) + B(3) \\ B(41) + B(3)$	•		
219 220 221 222 223 223 224	$\begin{array}{c} B(36) \neq B(3)\\ B(37) = 1 = 0\\ B(38) \neq B(3)\\ B(39) = B(3)\\ B(39) = B(3)\\ B(40) \approx B(3)\\ B(41) \neq B(3)\\ B(42) \approx B(3)\\ B(42) \approx B(3)\\ \end{array}$	 	алан алан Алан Алан Алан Алан Алан Алан Алан Алан	
219 220 221 222 223 224 225	B(30) = B(3) B(37) = 1 + 0 B(38) = B(3) B(39) = B(3) B(40) = B(3) B(40) = B(3) B(41) = B(3) B(42) = B(3) B(42) = B(3)	•		
219 220 221 222 223 224 225 224	B(30) = B(3) = B(4) = B(3) = B(4) = B(4) = B(3) = B(42) = B(3) =			
219 220 221 222 223 224 225 226 227	$ \begin{array}{c} R(30) \pm R(3) \\ B(37) \pm 1.0 \\ R(38) \pm B(3) \\ S(39) \pm B(3) \\ B(40) \pm B(3) \\ B(40) \pm B(3) \\ B(41) \pm B(3) \\ R(42) \pm B(3) \\ R(42) \pm B(3) \\ R(44) \pm R(3) \end{array} $			
219 220 221 222 223 224 225 224 225 226 227 228	$ \begin{array}{c} R(30) = \beta(3) \\ B(37) = 1 \\ 0 \\ R(38) = B(3) \\ S(39) = B(3) \\ B(39) = B(3) \\ B(40) = B(3) \\ B(41) = B(3) \\ B(42) = B(3) \\ B(42) = B(3) \\ B(44) = B(3) \\ B(45) = B(3) \end{array} $))) 		
219 220 221 222 223 224 225 226 227 228 229	$ \begin{array}{c} R(30) = \beta(3) \\ B(37) = 1 \\ 0 \\ R(38) = B(3) \\ B(39) = B(3) \\ B(39) = B(3) \\ B(40) = \beta(3) \\ B(41) = B(3) \\ B(42) = B(3) \\ B(42) = B(3) \\ B(44) = B(3) \\ B(44) = B(3) \\ B(44) = B(3) \\ B(44) = 1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\$			
219 220 221 222 223 224 225 226 227 228 229 230	B(30) = B(3) $B(37) = 1 = 0$ $B(33) = B(3)$ $B(3) = B(3)$ $B(40) = B(3)$ $B(40) = B(3)$ $B(40) = B(3)$ $B(41) = B(3)$ $B(42) = B(3)$ $B(44) = B(3)$ $B(45) = B(3)$ $B(46) = 1 = 0$			
219 220 221 222 223 224 225 226 227 228 227 228 229 230	$ \begin{array}{c} R(36) = \beta(3) \\ B(37) = 1 \\ 0 \\ R(38) = B(3) \\ S(39) = B(3) \\ B(39) = B(3) \\ B(40) = B(3) \\ B(41) = B(3) \\ R(42) = S(3) \\ 0 \\ R(42) = S(3) \\ R(44) = R(3) \\ R(45) = R(3) \\ R(45) = R(3) \\ R(45) = R(3) \\ R(47) = 0 \\ (3) \\ R(47) = 0 \\ R(3) \\ R(3) \\ R(47) = 0 \\ R(3) \\ R(3) \\ R(47) = 0 \\ R(3) $			
219 220 221 222 223 224 225 226 227 228 229 230 231	$ \begin{array}{c} R(36) = \beta(3) \\ B(37) = 1 \\ 0 \\ R(38) = B(3) \\ B(39) = B(3) \\ B(39) = B(3) \\ B(40) = B(3) \\ B(41) = B(3) \\ B(42) = B(3) \\ B(42) = B(3) \\ B(44) = B(3) \\ B(44) = B(3) \\ B(46) = 1 \\ 0 \\ P(47) = B(3) \\ B(48) = B(3$			
219 220 221 222 223 224 225 226 227 228 229 230 231 232	$ \begin{array}{c} R(30) = \beta(3) \\ B(37) = 1 \\ 0 \\ R(38) = B(3) \\ B(39) = B(3) \\ B(39) = B(3) \\ B(40) = \beta(3) \\ B(40) = \beta(3) \\ B(42) = B(3) \\ B(42) = B(3) \\ B(44) = B(3) \\ B(46) = 1 \\ 0 \\ P(47) = \beta(3) \\ B(49) = B(3) \\ B(49) = B(3) \end{array} $			
219 220 221 222 223 224 225 224 225 226 227 228 229 230 231 232 233	$ \begin{array}{c} R(36) = \mathfrak{s}(3) \\ \mathfrak{s}(37) = 1 \\ \mathfrak{s}(38) = \mathfrak{s}(3) \\ \mathfrak{s}(39) = \mathfrak{s}(3) \\ \mathfrak{s}(39) = \mathfrak{s}(3) \\ \mathfrak{s}(40) = \mathfrak{s}(3) \\ \mathfrak{s}(41) = \mathfrak{s}(3) \\ \mathfrak{s}(42) = \mathfrak{s}(3) \\ \mathfrak{s}(42) = \mathfrak{s}(3) \\ \mathfrak{s}(43) = \mathfrak{s}(3) \\ \mathfrak{s}(44) = \mathfrak{s}(3) \\ \mathfrak{s}(46) = 1 \\ \mathfrak{s}(3) \\ \mathfrak{s}(46) = \mathfrak{s}(3) \\ \mathfrak{s}(46) = \mathfrak{s}(3) \\ \mathfrak{s}(56) = \mathfrak{s}(56) \\ \mathfrak{s}(56) = \mathfrak{s}(56) \\ \mathfrak{s}(56) \\ \mathfrak{s}(56) \\ \mathfrak{s}(56) = \mathfrak{s}(56) \\ \mathfrak{s}($			
219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234	$ \begin{array}{c} R(30) = \beta(3) \\ = \beta(37) = 1 \\ = 0 \\ R(38) = 8(3) \\ = 8(39) = 8(3) \\ = 8(39) = 8(3) \\ = 8(41) = 8(3) \\ = 8(42) = 8(3) \\ = 8(42) = 8(3) \\ = 8(42) = 8(3) \\ = 8(42) = 8(3) \\ = 8(42) = 8(3) \\ = 8(3) $			
219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 231 232	$ \begin{array}{c} R(30) = \beta(3) \\ B(37) = 1 \\ 0 \\ R(38) = B(3) \\ B(39) = B(3) \\ S(39) = B(3) \\ B(40) \approx \delta(3) \\ B(40) \approx \delta(3) \\ B(42) \approx B(3) \\ B(42) \approx B(3) \\ B(44) = B(3) \\ B(44) = B(3) \\ B(46) = 1 \\ 0 \\ P(47) \approx \delta(3) \\ B(46) = B(3) \\ B(49) = B(3) \\ B(50) = B(3) \\ B(51) \approx b(3) \\ B(52) \approx - D(3) \\ \end{array} $		[3]	
219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235	$ \begin{array}{c} R(36) = \beta(3) \\ = \beta(3) \\ = \beta(3) \\ = 1, 0 \\ R(38) = 8(3) \\ =$	JS(12-	[3]	
219 220 221 223 224 225 224 225 226 227 228 229 230 231 232 233 234 235 234	$ \begin{array}{c} R(36) = \beta(3) \\ = \beta(37) = 1 \\ = 0 \\ R(38) = 8(33) \\ = 8(39) = 8(3) \\ = 8(39) = 8(3) \\ = 8(39) = 8(3) \\ = 8(42) = 8(3) \\ = 8(33) = 0(3) \\ = 8(42) = 8(3) \\ = 8(42) = 8(3) \\ = 8(31) $	JS(12- N(12-T	[3) {	
219 220 221 222 223 224 225 226 227 228 227 228 230 231 232 231 232 233 234 235 234 235 236 237	$ \begin{array}{c} R(30) = \beta(3) \\ = \beta(37) = 1 \\ = 0 \\ R(38) = 8(3) \\ = 8(38) = 8(3) \\ = 8(39) = 8(3) \\ = 8(41) = 8(3) \\ = 8(42) = 8(3) \\ = 8(42) = 8(3) \\ = 8(42) = 8(3) \\ = 8(42) = 8(3) \\ = 8(3)$)))))))))))))))))))	(د 13)	
219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 234 235 234 235 234 235 234	$ \begin{array}{c} R(36) = \mathfrak{s}(3) \\ = \mathfrak{s}(37) = 1 \\ = 0 \\ R(38) = \mathfrak{s}(33) \\ = \mathfrak{R}(33) \\ = \mathfrak{R}(33$	JS (1 2- N (T 2 - T	[3] {\label{eq:starses}}	
219 220 221 223 223 224 225 226 225 226 227 228 229 230 231 232 233 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235	$ \begin{array}{c} R(36) = \mathfrak{s}(3) \\ \mathfrak{s}(37) = 1 \\ \mathfrak{s}(38) = \mathfrak{s}(3) \\ \mathfrak{s}(39) = \mathfrak{s}(3) \\ \mathfrak{s}(39) = \mathfrak{s}(3) \\ \mathfrak{s}(40) = \mathfrak{s}(3) \\ \mathfrak{s}(41) = \mathfrak{s}(3) \\ \mathfrak{s}(42) = \mathfrak{s}(3) \\ \mathfrak{s}(44) = \mathfrak{s}(3) \\ \mathfrak{s}(44) = \mathfrak{s}(3) \\ \mathfrak{s}(44) = \mathfrak{s}(3) \\ \mathfrak{s}(44) = \mathfrak{s}(3) \\ \mathfrak{s}(46) = 1 \\ \mathfrak{s}(3) \\ \mathfrak{s}(46) = \mathfrak{s}(3) \\ \mathfrak{s}(46) = \mathfrak{s}(3) \\ \mathfrak{s}(50) = \mathfrak{s}(3) \\ \mathfrak{s}(51) = \mathfrak{s}(3) \\ \mathfrak{s}(52) = \mathfrak{s}(3) \\ \mathfrak{s}(52) = \mathfrak{s}(3) \\ \mathfrak{s}(54) = \mathfrak{s}(3) \\ \mathfrak{s}(54) = \mathfrak{s}(3) \\ \mathfrak{s}(55) = \mathfrak{s}(3) \\ \mathfrak{s}(55) = \mathfrak{s}(3) \\ \mathfrak{s}(55) = 1 \\ \mathfrak{s}(3) = \mathfrak{s}(3) \\ \mathfrak{s}(56) \\ \mathfrak{s}(56) = \mathfrak{s}(3) \\ \mathfrak{s}(56) \\ \mathfrak{s}(5$	JS (1.2- N (T.2 - T	[3) {}	
219 220 221 222 223 224 225 226 227 228 230 231 232 233 231 232 233 234 235 236 247 238 236 247 238 234	$ \begin{array}{c} R(36) = \beta(3) \\ = \beta(37) = 1 \\ = 0 \\ R(38) = 8(3) \\ = 8(39) = 8(3) \\ = 8(39) = 8(3) \\ = 8(39) = 8(3) \\ = 8(42) = 8(3) \\ = 8(42) = 8(3) \\ = 8(42) = 8(3) \\ = 8(42) = 8(3) \\ = 8(42) = 8(3) \\ = 8(3) \\ = 8(3) = 8(3) \\ $	JS (1 2- N(T 2 - T	۲3) (ر	
219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 24 24 24 25 223 224 223 224 224 225 224 225 224 225 224 225 224 225 224 225 224 225 224 225 224 225 225	$ \begin{array}{c} R(36) = \beta(3) \\ = \beta(3) \\ = \beta(3) \\ = 1, 0 \\ R(38) = 8(3) \\ = 8(39) = 8(3) \\ = 8(39) = 8(3) \\ = 8$	JS (1 2- N (T 2 - T	[3] {\	
219 220 221 223 224 225 226 225 226 227 230 231 232 233 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 235 235 235 235 235 24 24 25 24 24 25 24 25 25 24 25 25 24 25 25 26 26 27 27 27 27 27 27 27 27 27 27 27 27 27	$ \begin{array}{c} R(36) = \mathfrak{s}(3) \\ = \mathfrak{s}(37) = 1 \\ = 0 \\ R(38) = \mathfrak{s}(3) \\ = \mathfrak{s}(39) = \mathfrak{s}(3) \\ = \mathfrak{s}(39) = \mathfrak{s}(3) \\ = \mathfrak{s}(39) = \mathfrak{s}(3) \\ = \mathfrak{s}(40) = \mathfrak{s}(3) \\ R(42) = \mathfrak{s}(3) \\ R(49) = \mathfrak{s}(3) \\ R(49) = \mathfrak{s}(3) \\ R(50) = \mathfrak{R}(3) \\ R(50) = \mathfrak{R}(3) \\ R(52) = \mathfrak{s}(3) \\ R(52) = \mathfrak{s}(3) \\ R(53) = \mathfrak{R}(3) \\ R(53) = \mathfrak$	us (1 2- N(T 2 - T	[3) {	
219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 236 237 238 236 247 238 236 247 238 236 247 238 236 247 238 236 244 235 236 231 232 235 236 237 236 237 237 237 237 237 237 237 237 237 237	$ \begin{array}{c} R(36) = \beta(3) \\ = \beta(37) = 1 \\ = 0 \\ R(38) = 8(3) \\ = 8(38) = 8(3) \\ = 8(39) = 8(3) \\ = 8(39) = 8(3) \\ = 8(39) = 8(3) \\ = 8(39) = 8(3) \\ = 8(42) = 8(3) \\ = 8(42) = 8(3) \\ = 8(42) = 8(3) \\ = 8(42) = 8(3) \\ = 8(42) = 8(3) \\ = 8(31) $	JS (1 2- N (T 2 - T	[3] }	
219 220 221 222 223 224 225 226 227 228 227 228 230 231 232 234 235 234 235 234 235 234 235 236 231 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 24 24 24 24 24 24 24 24 24 24 24 24 24	$ \begin{array}{c} R(36) = \mathfrak{s}(3) \\ = \mathfrak{s}(37) = 1 \\ = 0 \\ R(38) = \mathfrak{s}(33) \\ = \mathfrak{R}(33) \\ = \mathfrak{R}(33$	JS (1 2- N (T 2 - T	[3) {\	
219 220 221 223 224 225 226 227 228 229 230 231 232 233 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 234 235 240 240 240 244 243 244	$ \begin{array}{c} R(36) = \mathfrak{s}(3) \\ = \mathfrak{s}(37) = 1 \\ = 0 \\ R(38) = \mathfrak{s}(3) \\ = \mathfrak{s}(39) = \mathfrak{s}(3) \\ = \mathfrak{s}(39) = \mathfrak{s}(3) \\ = \mathfrak{s}(39) = \mathfrak{s}(3) \\ = \mathfrak{s}(40) = \mathfrak{s}(3) \\ = \mathfrak{s}(42) = \mathfrak{s}(3) \\ = \mathfrak{s}(3) = s$	us (1 2- N(T 2 - T	[3) {	
219 220 221 222 223 224 225 224 225 226 227 230 231 232 2331 232 2331 232 2334 235 236 247 238 236 247 238 234 235 244 245 244 245	$ \begin{array}{c} R(36) = \beta(3) \\ = \beta(3) $	JS (1 2- N(T 2 - T	[3) }	
219 220 221 222 223 224 225 226 227 228 226 237 230 231 232 234 235 234 235 234 235 234 235 234 235 234 235 234 235 244 244 244 244 246	$ \begin{array}{c} R(36) = \beta(3) \\ = \beta(3) \\ = \beta(3) \\ = R(38) \\ = R(38) \\ = R(38) \\ = R(39) \\ = R(39) \\ = R(39) \\ = R(38) \\ = R(3$	JS (1 2- V(T 2 - T	[3] {\	
219 220 221 222 223 224 225 226 227 229 230 231 232 233 235 236 231 232 233 235 236 231 235 236 231 235 236 231 235 240 240 240 246 246 246 236 236 236 236 236 236 236 236 236 23	$ \begin{array}{c} R(36) = \mathfrak{s}(3) \\ \mathfrak{s}(37) = 1 \\ \mathfrak{s}(38) = \mathfrak{s}(3) \\ \mathfrak{s}(39) = \mathfrak{s}(3) \\ \mathfrak{s}(39) = \mathfrak{s}(3) \\ \mathfrak{s}(40) = \mathfrak{s}(3) \\ \mathfrak{s}(41) = \mathfrak{s}(3) \\ \mathfrak{s}(41) = \mathfrak{s}(3) \\ \mathfrak{s}(42) = \mathfrak{s}(3) \\ \mathfrak{s}(42) = \mathfrak{s}(3) \\ \mathfrak{s}(44) = \mathfrak{s}(3) \\ \mathfrak{s}(44) = \mathfrak{s}(3) \\ \mathfrak{s}(44) = \mathfrak{s}(3) \\ \mathfrak{s}(44) = \mathfrak{s}(3) \\ \mathfrak{s}(46) = \mathfrak{s}(3) \\ \mathfrak{s}(46) = \mathfrak{s}(3) \\ \mathfrak{s}(50) = \mathfrak{s}(3) \\ \mathfrak{s}(50) = \mathfrak{s}(3) \\ \mathfrak{s}(51) = \mathfrak{s}(3) \\ \mathfrak{s}(52) = \mathfrak{s}(3) \\ \mathfrak{s}(53) = \mathfrak{s}(3) \\ \mathfrak{s}(53$	JS(12- N(T2-T	(د (۲	

248 ذ = ار. 249 M-d 250 MSA =0 251 MS8 =0 252 1 8 253 CALL MPRD(A, B, R, N, M, MSA, MSB, L) 254 03 11 1=1,24 255 // A(1)=R(1) C ſ THE SYSTEM FORCE MATRIX FOR THE SOURCE MECHANISM. ι 256 3(1)=91 251 B(2)=72 258 is(3)=P3 259 3(4)=P4 B(5)=P5 260 B(6)=P6 261 262 b(7)=P1 263 n(8)=P3 264 N= 3 M=8 265 M5A=0 266 267 MSRED 268 L - E CALL MPRD(A, B, R, N, M, MSA, MSB, L) 269 210 XX=R(1) 271 $Y_{1}Y = R(2)$ 212 R1=R(3) WRITE(6,200)P2,XX,YY,RF 213 209 FURMAT (1H3,5X, [12.6,8X, F12.6,8X, F12.6,8X, F12.6] 214 275 II (P2.10.300.0) GO TO 6 276 Gu 13 5 277 o StuP 276 END \$ENTRY t. GMTK • GMIR C GMTR Ċ SUBROUTINE GMTRA GMTR r G412 Ĺ UMTR U PURPOSE TRANSPUSE A GENERAL MATRIX GMTR C ι, GMTK USAGE GMTK Ċ CALL GMTRA(A.R.N.M) GMTR 100 Ċ GMTR 110 ١. **JMT**K 120 (. DESCRIPTION OF PARAMETERS $\begin{array}{cccc} A & - & NAME & UF & MATRIX & 10 & BE & TRANSPOSED \\ R & - & NAME & DF & RESULTANT & MATRIX \\ \end{array}$ ۱, GMTR 130 GMTK 140 C, 4 - NUMBER OF ROWS OF A AND COLUMNS UN R GMTR 150 ι. A - NUMBER OF COLUMNS OF A AND ROWS OF R GMT - 160 ŧ. GMFK 170 (ι, REMARKS GMTR 180 MATRIX R LANNOT OF IN THE SAME EJEATION AS MATRIX A GMTR 190 L. HATRILES A AND R MUST BE STURED AS JENERAL MATRICES GMTE 200 ŧ. GMTR 210 ١. SUBFOUTINES AND FUNCTION SUBPRUGRAMS REQUIRED GMT × 220 C. GMTR 230 NUNE L. GMTR 240 C

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	C C C C	METHJO TRANSPOSE N SY M MATRIX A TJ FURM M BY N MATRIX 2	GMTK GMTK GMTK	250 260 270
	Ċ		GMTR.	290
279 280		SUBROUFINE GATRA(A;R,N,M) DEMENSETAN A(E),R(E)	GMTR	300
	C.		GMTK	320
281 282		$L(x \neq 0)$ (b) 10 $L = 1 \cdot N$	GMTR	330 340
283		I J = I - N	GMTR	350
284 285		D.5 = 10 = J = 1.4 M	GMTR	363
286		1R = IR + 1	GMTR	380
287		$10 \ R(\mathbf{I}\mathbf{K}) = \mathbf{A}(\mathbf{I}\mathbf{J})$	GMER	390
288		END	GMTR	400
	с		MDUD	1.1
	ĉ	• • • • • • • • • • • • • • • • • • • •	MPRO	. 20
	L		MPRD	30
	C C	SUBRUUTINE MPRU	MPRJ	40 50
	L.	PURPUSE	MPRD	60
	C	MULTIPLY TWO MATRICES TO FORM A RESULTANT MATRIX	MPRJ	. 70
	C	USAGE	MPRD	90
	C	LALL MPRD (A, B, R, N, M, MSA, MSB, L)	MPRJ	100
	L L	DESCRIPTION OF PARAMETERS	MPRD	120
	Ċ	A - NAME OF FIRST INPUT MATRIX	MPR)	130
	ر د	B - NAME OF SECOND INPUT MATRIX	MPRD	140
	C,	N - NUMBER OF DOIPOT MATRIX N - NUMBER OF ROWS IN A AND R	MPRD MPR)	160
	Ċ,	M - NUMBER JE CULUMNS IN A AND RUWS IN B	мркр	170
	С С	MSA – ONE DIGIT NUMBER FUR STURAGE MODE DE MATRIX A D – GENERAL	MPRO	180
	С.	1 - SYMMETRIC	MPRU	200
	C	2 - DIAGONAL	MPRO	210
	L L	L – NUMBER JE COLUMNS IN BAND R	MPRD	230
	C.		MPR)	240
	C C	REMARKS ΜΔΙΡΙΧ κ. CANNILISE IN THE SAME LOCATION AS MATRICES A OK A	MPRD	250
	Ğ	NUMBER OF COLUMNS OF MATRIX A MUST BE EQUAL TO NUMBER OF ROW	MPRO	270
	Ċ	UF MAIKIX B	MPRO	280
	С. С.	SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED	MPRJ	300
	C.	1.00	MPRD	310
	С С	METHOD	MPRO	320
	č	THE M BY L MAINIX & IS PREMULTIPLIED BY THE N BY M MAIKIX A	МРКО	340
	C.	AND THE RESULT IS STORED IN THE NIHY C MATRIX R. THIS IS A ROW TATE , OLIMAN REPORT T	MPRO	350
	C	NOW ENTO COLOMN PRODUCT. THE FOLLOWING TABLE SHOWS THE STORAGE MODE OF THE OUTPUT	MPRD	370
	C	MATRIX FOR ALL COMBINATIONS OF INPUT MATRICES	MPRO	380
	C C	A B R GENERAL GENERAL GENERAL	MPRD	370 400
	С.	GENERAL SYMMETRIL GENERAL	MPRD	410
	C	GENERAL DIAGUNAL GENERAL	MP R D	420

	C			SYMMETRIC	GENERAL	GENERAL	MPRD	430
	С			SYMMETRIC	SYMMETRIC	GENERAL	MPRD	440
	С			SYMMETRIC	DIAGONAL	GENERAL	MPRO	450
	ç			DIAGONAL	GENERAL	GENERAL	MPRD	460
	C			DIAGONAL	SYMMETRIC	GENERAL	MPRD	470
	C			DIAGUNAL	DIAGUNAL	DIAGUNAL		480
	ř						MPRD	500
	č						MPRO	510
290			SUBROUTINE MPRD	A . B . R . N . M . MS A . I	MSB,L)		MPRD	520
291			DIMENSION A(1), E	(1),R(1)			MPRD	530
	C						MPRD	540
	с с		SPECIAL CASE	FUR DIAGUNAL B	YDIAGUNAL		MPRU	550
202	L		MS=NSA*10+MSB				MPRO	570
293			IF(MS+22) 30.10.	30			MPRD	580
294		LO	DU 20 I=1.N				MPRD	590
295		20	R(I)=A(I)*B(I)				MPRD	600
296			RETURN				MPRD	610
	С						MPRD	620
	C		ALL OTHER CAS	ES			MPRO	630
20.7	L	10	10-1				MPRU	640
208		10	1N-1 DD 90 K=1.1				MPRD	660
299			D.) 90 J=1.N				MPRD	670
300			R(1R)=0				MPRD	680
301			DO 80 I=1,M				MPRD	690
302			IF(MS) 40,60,40				MPRD	700
303		40	CALL LOC(J,I,IA	N, M, MSA)			MPRD	710
304			CALL LOC(I,K,IB,	M.L.MSB)			MPRD	720
206		50	IF(IA) 50,80,50	1				740
300		60	$[\Lambda = N * (1 - 1) + 1$	18 - 19 - 19 - 19 - 19 - 19 - 19 - 19 -			MPRD	750
308			[B=M*(K-1)+1				MPRD	760
309		70	R(IR) = R(IR) + A(IA))*B(IB)			MPRD	770
310		80	CONTINUE				MPRD	780
311		90	IR = IR + 1				MPRJ	790
312			RETURN				MPRD	800
داد			END				MPRU	810
	Ċ.						1.00	10
	č							20
	С			,	e.		LOC	30
	С		SUBROUTINE LO	C			LOC	40
	C						LUC	50
	C.			VECTOR CHRCCRT	T CID AN ELEMENT			50
	ĉ		SPECIEIED	STORAGE MODE	FI FUR AN ELENENT	IN A MAINIA UP		80
	c		Ji Con ICD	STURROL HODE			LOC	90
	č		US AGE				LOC	100
	C		CALL LUC (I.J.IR.N.M.MS)			LUC	110
	C						LOC	120
	C		DESCRIPTION C	DF PARAMETERS	.		LOC	130
	C		I - ROW	NUMBER OF ELEMI	ENI		100	140
	Ċ		יד אין	וייזיא אוטייזיטיביא טוד (ונידאאיד ערבידנוס פי	ELEMENI IRSCRIPT			120
	C.		N = NUMP	ER OF ROWS IN 1	MATRIX		1.00	170
	č		M - NUME	DER OF COLUMNS	IN MATRIX		LOC	180
	Ċ		MS - ONE	DIGIT NUMBER F	DR STORAGE MODE D	F MATRIX	LOC	190
	C		0 -	GENERAL			LOC	200

	ι.		1 - SYMMET	RIC			i ac	210
	(<i>.</i>		2 - DIAGUN	41			LUC	210
	C						LOC	220
	С.	REMARKS					LUC	230
	L	NUNE					LUL	240
	C						LUC	250
	C	SUBPOUTIN	NES AND EUNC	TION SUBPRO	GRAMS RECITED		LUC	260
	С	NUNE		Sector Source	ISRAIS REWSIRED		LUC	270
	C.						LUC	280
,	r,	METHUD					LUC	290
	C	M S= 0	SUBSCRIPT	IS COMPLITED	FOR A MATRIX VIT	IL NEW CLEMENTS	LUC	300
	С		IN STORAGE	CENERAL M	ATD (V)	H N#M ELEMENIS	LOC	310
(C	M5=1	SUBSCRIPT	IS COMPUTED		11	LUC	320
. (С		STURAGE LUG	DED TREAMC	LE DE SYMMETRIC	H N#(N+1)/2 IN	LOC	330
	C .		FLEMENT IS		DIANCH AD DUDTION	AIRIXJ. IF	LOC	340
(C		CORRE SPOND	ING ELEMENT	IN UPDER TOTANG	SUBSCRIPT IS	LUC	350
	C	MS=2	SUBSCRIPT	IS CUMPHIEN	EOD A MATURY WET		LUC	360
(IN STORAGE	(DÍAGONAL	FUR 4 MAIRIX WIT	H N ELEMENTS	LOC	370
1	3		LE ELEMENT	IS NOT ON	DIACONAL (AND THE	NAL MAIKIX).	LUC	380
(<u> </u>		STURAGE). I	D IC CET T	O ZERO	REFURE NUL IN	LUC	390
(STORAGE I	N 13 3E1 1	U ZERU.		LOC	400
(;						LOC	410
(•••••	•L0C	420
		SUBROUTINE I	UL (I.J.IR.N.	M. MS)			L 05	430
(;	-		114/13/			LUC	440
		1 X = 1					LOC	450
		JX = J					LUC	460
		[F(MS-1] 10,	20.30				LUC	470
	10	1RX =N*(JX-1)	+1X				LUC	480
		GU IU 36		•			LUG	490
	20	IF(IX-JX) 22	.24.24				LOC	500
	22	$IRX = IX + (JX \neq J)$	X-JX1/2				LUC	510
		GU I O 36					LOC	520
	24	IRX=JX+(IX*I)	x-1x)/2				LUC	530
		60 10 36					LUC	540
	30	IKX=0					LOC	550
		[F(IX-JX) 36.	. 2.30				LUC	560
	32	19 X=1 X					LUC	570
	36	IR = IR X					LOC	580
		RETURN					£ 0C	590
		END					LUC	600
							1.111.	610

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\$JUB TIME=55, NOSUBCHK, LIBLIST С **** ***** * * * С ×. Ċ. * * C CASE II * C × С * * C ate: * С С * С **D**E x c × Ċ FOUR-LINK MECHANISM * ά¢ С * С *** 1 DJUBLE PRECISION L1.CL1.L2.CL2.L3.CL3.L4.CL4.L5.CL5.K1.CK1.K2.CK2. *K3,CK3,K4,CK4,K5,CK5,AA,CAA,BB,CBB,CC,CCC,DD,CDD,EE,CEE,FF,CFF,T2, * T3, CT3, I4, CT4, 0M2, CUM2, 0M3, COM3, 0M4, CUM4, AJ, CAJ, BJ, CBJ, CJ, CCJ, DJ, C *DJ, EJ, CEJ, FJ, CFJ, ALP, CALP, ALPH2, CALPH2, ALPH3, CALPH3, ALPH4, CALPH4, D *COS .DSIN. DATAN. DSQRT. DCOT. CX. CCX. SX. CSX. CTX. CCTX. A1. CA1. B1. CB1. C1. *CC1,D1,CD1,E1,CE1,F1,CF1,G1,CG1,H1,CH1,H1,CH1,R1,CR1,PI,CA,CCA,M1, *CMI, ME, CME, XP, CXP, YP, CYP, XX, CXX, YY, CYY, NXP, NCXP, NYP, NCYP *,XPP,YPP,BETA,Z1,Z2,K,CBTA,SBTA,TBTA *, UL XX, RL XX, TCPP X, TCPPY 2 DIMENSION A(64), B(64), R(64), U(64), F(64) 3 L1=10.0 L2=10.0 4 5 L3 = 30.06 L4=25.0 7 15 = 30.08 K1 = 15/119 K2=L5/L4 10 K 3= (L1*L1-L3*L3+L4*L4+L5*L5)/(2.0*L1*L4) 11 K4=L5/L3 12 K5=(L4*L4-L5*L5-L1*L1-L3*L3)/(2.0*L1*L3) WRITE(6,100) 13 14 100 FORMAT(1H1,9X, 'DEGREES', 13X, 'X-DISP.OF P',8X, 'Y-DISP.OF P',10X, 'Z-*RUT.OF P!} 15 P1=3.142857143 С C S---- THE SPEED OF ROTATION OF THE INPUT LINK = 300 R.P.M. С 16 5=300.0 17 BM2=(2.0*P1*S)/60.0 18 P2 = -10.019 5 P2 = P2+10.0 I2 = (P2 * 2.0 * PI) / (360.0)20 21 AA = DCUS(T2) + K3 - K1 - (K2 * DCOS(T2)) $BB = -2.0 \times DSIN(T2)$ 22 23 $CC = K1 + K3 - (1 \cdot 0 + K2) + DCUS(T2)$ 24 DD=(K4*DCUS(T2))+DCDS(T2)+K5-K1 25 $EE = -2.0 \neq DSIN(T2)$ FF = (K4*DCUS(T2)) - DCUS(T2) + K5+K1 26 13=2.0*(DATAN((-EE-DSJRT(EE*EE-4.0*DD*FF))/(2.0*D0))) 14=2.0*(DATAN((-BB-DSJRT(BB*BB-4.0*AA*CC))/(2.0*AA))) 27 28 29 ALP=P1/3.0 30 XP = (L1*UCOS(T2))+(L2*UCOS(ALP+T3)) 31 YP = (L1*DSIN(T2))+(L2*DSIN(ALP+T3)) С *THE COUPLER COGNATE DIMENSIONS ARE AS FOLLOWS:-С

32	K=L2/L3
33	CL4=DSURT((L2*L2)+(L3*L3)-(2.0*L2*L3*DCOS(ALP)))
34	CL3=L4*CL4/L3
35	CL 2=K★L 4
36	CL5=DSJRT[([K*L5]**2]+(L5*L5]-[2.0*L5*L5*K*DCDS(ALP])]
37	
38	$LBIA = \{(L3*L3)+(LL4*LL4)-(L2*L2)\}/(2*L3*L2)$
39	$SBTA= DSQRT(1.0-(CBTA) \neq 2)$
40	IB TA = SB TA / C B TA
41	BETA= DATAN(TBTA)
42	CALP=PI-(BEIA+ALP)
43	
44	
45	(K3=(L13+L13+L14+L1+L1+L1+L1+L15+L15)/(2+U+L1+L1+L14)
46	
41	(K)=((L]*(L]+(L])*(L])*(L])*(L])*(L])*(L]*(L])*(L])*(
48	CAA = DCUS(12) + CK3 - CK1 - CK2 + DCUS(12))
49	$CBS = -2.0 \forall D SIN(12)$
50	
51	$UD = \{(C, A \neq D, C, U, (T, Z)) + D, US, (T, Z) + U, U, US, (T, Z) + U, US, (T, Z) + U, US, (T, Z) + U, US, ($
52	CEE = -2.0 +DSIN(12)
53	CFF = (CK4 * DCUS(12)) - DCUS(12) + (KS) + CK1
54	C13=2.0*(DATAN((-LE-DSQR)(LEE-ECE-4.0*LDD*LDD*LF))/(2.0*LDD)))
55	$CI4=2 \cdot 0 \neq 0 \Delta IA IA I (1-0 B - 0 SQR 1 (0 B + 0 B - 0 B + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0$
56	XPP = (CLI * DCUS (IZ)) + (CLZ * DCUS (PI - ICALP - CI3))
57	$YPP = \{LLI \neq USIN(IZ)\} + \{LLZ \neq USIN(PI - (LALP - USI)\}$
58	COM2=(2.0*PI*S)/60.0
59	CALPH2=0.0
60	COM 3 = (CL1 * COM2 * DSIN(12 - C14)) / (CL3 * DSIN(C13 - C14))
61	COM4= (CL1+CDM2+DSIN(CT3-T2))/(CL4+DSIN(CT4-CT3))
62	CAJ=CL4*DSIN(CT4)
63	CBJ=CLJ=DSIN(CT3)
64	CCJ = -(CL1*CALPH2*DSIN(12)) - (CL1*CDM2*DCM2*DCUS(12)) + (CL3*CUM3*CUM3*CUM3)
·	**DCUS([13]) - ([L4*CUM4*CUM4*DCUS([14])
65	CDJ=CL4*DCDS(C14)
66	CFJ=CL3*DCOS(CT3)
67	$CF J = -\left(CL I \neq CALPH2 \neq DC OS (T2)\right) + \left(CL I \neq COM2 \neq COM2 \neq DS IN (T2)\right) - \left(CL 3 \neq COM3 \neq COM$
	**US IN(L(3))+(L(4*LUM4*LUM4*USIN(L(4))
68	(AL PH3 = (CL J * CD J - (AJ * CF J)) ((CAJ * CE J - CBJ * CD J)
69	LAEPH4=(LLJ=LEJ=LEJ=LEJ=LEJ=LEJ=LEJ=LEJ=LEJ=LEJ=
70	UXPA=-[UL1+UM2+UM2+UU03(12)]-(UL1+UL1PH2+U3)N(12)]+(UL2+UM3+U)M
	* 3*DLUS((ALP+(13))+(L)(2*CALPH3*USIN((ALP+C)3))
11	$U \neq A^{-} \{ U \mid A^{-} \mid U \mid A^{-} \mid A \mid A \mid A^{-} \mid A \mid $
	*3*DSIN((ALP-CI3))-(CL2*CALPH3*DCUS(CALP-CI3))
12	$(XPF = (XPA + 2 \cdot 0) (12 \cdot 0 + 32 \cdot 1/8)$
13	$CYP = CYPA * 2 \cdot 0/(12 \cdot 0 * 32 \cdot 1/8)$
14	CAT = DCUS(TZ)
75	LA1=DSIN(12)
76	CC1=DCDS(C14)
11	C(D) = -(DS) IN(12)
78	CE I = -DCOS(12)
19	
80	$U_0 = \{U_1 \ge V_0 \cup U_0 \} \{1 \ge 1 \ge U_0 \} \{1 \ge 1 \le U_1 \ge U_1 \ge 1 \ge 1 \le U_1 \ge U_0 \} \{1 \ge 1 \ge U_0 \ge U_0 \ge U_0 \ge U_0 \} \{1 \ge 1 \ge U_0 = U_0 \ge U_0 = U$
81	UH I = (ULZ + ULUS (IZ) + ULUS (UALP - UIZ) - (ULZ + USIN(IZ) + USIN(UALP - UIZ))
82	$(1) = (L_2 + U_U + U_1 + 1) + (L_2 + U_1 + U_1$
	*SIN(L14)*0CUS(LALP-L13)]+(LL3*USIN(L14)*USIN(L13)]
83	
	$ \hat{\mathbf{v}} \left[\mathbf{U} \right] \mathbf{v} \in \mathbf{H} \left[\mathbf{J} - \left(\mathbf{U} \in \mathbf{I} \neq \mathbf{U} \in \mathbf{I} \right) \right] $
84	
85	LSX=USIN(LT3-LT4)

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t

86	C	CCTX=CCX/CSX	
	C C	THE FURCE TRANSFURMATION MATRIX FUR THE CUGNATE FOR CASE#2.	
	С		
87		U(1) = -U(1)S((2ALP - C1))	
0.0			
0.0			
01		0 (+) - (0 (+) - (1 + 0 + 1 + 0 + 1) / (0 + 1)) = 0	
31		(1/2) = (1/1) + (0/1) = (1/1) + (1/1	
9 1		(1,1) = (1,1) + (1,1	
44		(1, 3) = 0 SIN(CALP-CL3) + CL2	
95		$U(\mathbf{y}) = D \times I \times (CA \mathbf{y} - C \mathbf{x})$	
46		U(1,0) = -DCDS(CA)P - (T,3)	
47	1.1	u(1) = 0.0	
98		U(12) = (CC1 + CH1 - CB1 + CI1)/CR1	
99		U(13) = (CA1 + CI1 - CC1 + CG1)/CR1	
100		U(14)=(CH1#CG1-CA1#CH1)/CR1	
101		U(15) = -(DCOS(CALP-CT3) + CCTX+CL2/CL3)	
102		U(16) = -DCUS(CALP-CT3) + CL2	
103		U(17)=0.0	
104		U(18) = 0.0	
105		U(19)=1.0	
106		U(20)=(CB1*CF1-CC1*CE1)/CR1	
107		U(21) = (CC1 + CD1 - CA1 + CF1) / CR1	
108		U(22) = (CA1*CE1-CB1*CD1)/CR1	
109		U(23) = CCTX/CL3	
110		U(24) = 1.0	
	C	TRANSPOSING THE FORCE TRANSFER MATRIX (CBETA) OF THE COGNATE.	
	C		
111			
113			
	ſ	GALE OFTRATURINI	
	č	THE TRANSPOSED FURCE-TRANSPER MATRIX IS MULTIPLIED BY THE	
	č	COGNATE FLEXIBILITY MATRIX -	
	č		
114		UU 88 I≈1,24	
115		88 A(I)=R(I)	
	С		
	С	*ALL LINKS ARE OF UNIFURM CRUSS-SECTION OF DIA.=0.5".	*
	C		
	С	*''CCA''-CRUSS-SECTIONAL AREA OF ALL LINKS.	*
116		CCA=0.1963495408.	
	С		
	С	***CME**-YOUNG'S MODULUS OF ELASTICITY FOR MATERIAL ALUMUNIUM.	*
117		CME=10000000.0	
	C		
	L	***CMI**-CRUSS-SECTIONAL MOMENT OF INERTIA.	*
118	c	CW1=0+0030014012	
	č	FUE ELEVIDIEITY MATDLY FOR THE COCNATE MECHANISM FICEFF	
	r r	THE FELADELITE MATRIX FOR THE COUNTE MECHANISM CITY .	
119	U	F(1)=C12/(CCA+CME)	
120		F(2)=0.0	
121		F(3) ≈ F(2)	
122		F(4) = F(2)	
123		F(5) = F(2)	
124		F(6) = F(2)	

125	F(7)=F(2)	
126	F(8)=F(2)	
127	F(9)=F(2)	
128	F(10)=(CL2*CL2*CL2)/(3.0*CME*CM1)	
129	F(11)=(CL2+CL2)/(2.0+CME+CMI)	
130	F(12)=F(2)	
131	F(13)=F(2)	
132	F(14) = F(2)	
133	F(15) = F(2)	
134	F(16) = F(2)	
135	F(17) = F(2)	
136	F(18) ≠ (CL2*CL2)/(2.0*CME*CML)	
137	F(19) = CL2/(CME * CMI)	
138	E(20) = E(2)	
139	$F(21) \pm F(2)$	
140	F(22) = F(2)	
140	F(23) = F(2)	
141		
142	F(25)-F(2)	
143	F(2)=F(2)	
144	F(20)=F(2) F(27)=F(2)	
145	F (2 /) = F (2) F (2 0) = C () // C C A + C NF)	
140	F(28)=UL1/(ULA*UME)	
147	F1291=F121	
148	F(30)=F(2)	
149	F(31) = F(2)	
150	F(32)=F(2)	
151	F(33) = F(2)	
152	F(34) = F(2)	
153	F(35) = F(2)	
154	F(36) = F(2)	
155	F(37)=(CL1+CL1+CL1)/(3.0+CCA+CME)	
156	F(38)=F(2)	
157	F(39) = F(2)	
158	F(40)=F(2)	
159	F(41) = F(2)	
160	F(42) = F(2)	
161	F(43) = F(2)	
162	F(44)=F(2]	
163	F(45)=F(2)	
164	F(46)=UL4/(ULA*UME)	
165	F(47)=F(2)	
166	F(48) = F(2)	
167	F(49)=F(2)	
168	F(50) = F(2)	
169	F(51)=F(2)	
170	F(52)=F(2)	
171	F(53) = F(2)	
172	F(54)=F(2)	
1/3	F(55)=CL3/(CCA*CME)	
174	F(56) = F(2)	
175	F(57) = F(2)	
176	F(58) = F(2)	
177	F (59) = F (2)	
178	F(60) = F(2)	
179	F(61) = F(2)	
180	F(62) = F(2)	
181	F(63)=F(2)	
182	F(64)≅CL3/(3.0*CME*CMI)	
183	N= 3	
184	M= 8	
185		MSA =0
------	--------	---
186		MSB=0
187		L= 8
188		CALL MPRD(A, F, R, N, M, MSA, MSB, L)
	C	
	C C	THE PRODUCT R IS MULTIPLIED BY THE FORCE-TRANSFER MATRIX.
189		DU 99 I=1,24
190	99	A(1)=R(1)
	C	THE FURCE TRANSFER MATRIX FUR CUGNATE FUR CASE#2.
191		U(1) = -DCOS(CALP - CT3)
192		U(2) = -DSIN(CALP-CT3)
193		U(3)=0.U
194		U(4)=(CE1+CI1+CF1+CH1)/CR1
195		U(5)=(CF1*CG1-CD1*C11)/CR1
196		U(6)=(CD1+CH1-CE1+CG1)/CR1
197		U(7) = -(CCTX + OSIN(CALP - CT3) + CL2/CL3)
198		U(8) = -DSIN(CALP - CT3) + CL2
199		U(9)=DSIN(CALP-CT3)
200		U(10) = +DCOS(CALP-CT3)
201		U(11)=0.0
202		U(12) = (CC1 * CH1 - CB1 * C11) / CR1
203		U(13) = (CA1 + CI1 - CC1 + CG1)/CR1
204		U(14) = (CB1 + CG1 - CA1 + CH1)/CR1
205		U(15) = -(DCOS(CALP-CT3) * CCTX * CL2/CL3)
206		U(16) = -DCUS(CALP-CT3) + CL2
207		U(17)=0.0
208		U(18) = 0.0
209		U(19)=1.0
210		U(20) = (UBI * UFI - UUI * UEI) / UKI
211		U(21) = (CC1 + CD1 - CA1 + CF1) / CR1
212		
213		$(1(23) \neq U(1X)(L3)$
214		
215		00 90 1=25,27
216	90	
217		U(28) = 1.0
218		DU 91 1=29,30
219	91	
220		
221	~~~	00 92 1=38+45
222	92	
223		
224	0.2	
220	91	U(1)=U(0)
220		((52) = 0(0)(0)(1) = 12)
221		((55)-0)(((5)-12))
220		
229		
230	07	
231	94	
232		
232		ς -γ Μ Ω
2.34		m= o Ms A =0
200		MCH -O
230		risp ≝γ I = Ω
231		CALL MPRD (A.U.R.N.M.MSA.MSB.L)
220		$\frac{111}{12}$
229		00 III ITAIAT A(1)=0(1)
240		

	C	
	C.	THE PRODUCT IS MULTIPLIED BY THE EXTERNAL FORCE MATRIX ""P"".
	1	
	C	
241		DNIY=0.098
242		GC≠32•178 * 12•0
243		LXPA=-((L1*DCDS(T2)*C0M2*C0M2)-(CL1*DSIN(T2)*CALPH2)+(CL2*DCOS(CAL
		$\pm P = (T3) \pm (DM3) = (DL2) \pm (SIN(CA) P = (T3) \pm (ALPH3)$
211		
244		C + P = -(L + D S + (D + Z + C + Z + C + C + D + C + C + D + D
		*P-C13)*CUM3*CUM3)-(CL2*DCUS(CALP-C13)*CALPH3)
245		CXDA=-(CL1*DSIN(T2)*CALPH2)-(CL1*DCUS(T2)*CUM2*COM2)
246		CYDA≒(JL1*DCDS(T2)*CALPH2)-(CL1*DSIN(T2)*COM2*(UM2)
247		$C \times E A = \pm (1 + 1) C (1 + 1) A = C (1 + 2) A = C (1 + 2$
241		
248		
		*)*COM3*COM3)+(CL3*DCOS(CT3)*CALPH3)
249		CVULI=CCA*CLI
250		CVUL2=CCA*CL2
251		CV013=CCA*C13
26.2		
4.76		
253		
254		CM2 =DNTY * CVUL2
255		CM3=DNTY*CVOL3
256		
257		
251		
200		
259		(P3=0.0)
260		CP4 =(CM1 * (CXDA * DCUS(T2)+CYDA *DSIN(T2)))/GC
261		CP5=(CM1*(CYDA*DSIN(T2)-CXDA*DCUS(T2)))/GC
262		CP6=(CM4*(CXEA*DCDS(LT4)+CYEA*DSIN(CT4)))/GC
263		(P_{1}) $(P_{$
2600		
204		
	C	
	Ç	THE SYSTEM FURCE MATRIX FOR THE CUGNATE MECHANISM.
	C	
265		B(1)=CP)
266		$R(2) = C P^2$
200		
201		
268		B(4)=CP4
269		B(5)=CP5
270		B(6)=CP6
271		AL7)=CP7
272		B(B)=(DB)
272		
213		N = 3
274		M=8
275		M 5A = 0
276		M 5 B = O
277		1 = 1
278		
210		CALL MDDD(A, B, P, N, M, MSA, MSB, L)
170		CALL MPRD (A, B, R, N, M, MSA, MSB, L)
279		CALL MPRD(A, B, R, N, M, MSA, MSB, L) CXX = R(1)
279 280		CALL MPRD(A,B,R,N,M,MSA,MSB,L) CXX=R(1) CYY=R(2)
279 280 281		CALL MPRD(A,B,R,N,M,MSA,MSB,L) CXX=R(1) CYY=R(2) C <t=r(3)< td=""></t=r(3)<>
279 280 281	C	CALL MPRD(A,B,R,N,M,MSA,MSB,L) CXX=R(1) CYY=R(2) C (T=R(3)
279 280 281	C	CALL MPRD(A,B,R,N,M,MSA,MSB,L) CXX=R(1) CYY=R(2) C <t=r(3) THE FOLLOWING TRANSFJRMATION LOCATES</t=r(3)
279 280 281	C C C	CALL MPRD(A,B,R,N,M,MSA,MSB,L) CXX=R(1) CYY=R(2) CKT=R(3) THE FOLLOWING TRANSFJRMATION LOCATES
279 280 281	C C C	CALL MPRD(A,B,R,N,M,MSA,MSB,L) CXX=R(I) CYY=R(2) C(T=R(3) THE FOLLOWING TRANSFJRMATION LOCATES
279 280 281		CALL MPRD(A,B,R,N,M,MSA,MSB,L) CXX=R(1) CYY=R(2) C <t=r(3) THE FOLLOWING TRANSFJRMATION LOCATES</t=r(3)
279 280 281	C C C C C	CALL MPRD(A,B,R,N,M,MSA,MSB,L) CXX=R(1) CYY=R(2) C <t=r(3) THE FOLLOWING TRANSFJRMATION LOCATES THE GOGNATE IN ITS TRUE</t=r(3)
279 280 281	C C C C C C C C	CALL MPRD(A,B,R,N,M,MSA,MSB,L) CXX=R(I) CYY=R(2) C (T=R(3) THE FOLLOWING TRANSFJRMATION LOCATES THE COGNATE IN ITS TRUE
279 280 281	C C C C C C C C C C C C C C C C C C C	CALL MPRD(A,B,R,N,M,MSA,MSB,L) CXX=R(I) CYY=R(2) C(T=R(J) THE FOLLOWING TRANSFJRMATION LOCATES THE COGNATE IN ITS TRUE
279 280 281	00000000000000000000000000000000000000	CALL MPRD(A,B,R,N,M,MSA,MSB,L) CXX=R(1) CYY=R(2) C(T=R(3) THE FOLLOWING TRANSFJRMATION LOCATES THE COGNATE IN ITS TRUE POSITION
279 280 281		CALL MPRD(A,B,R,N,M,MSA,MSB,L) CXX=R(I) CYY=R(2) C (T=R(3) THE FOLLOWING TRANSFJRMATION LOCATES THE COGNATE IN ITS TRUE POSITION POSITION

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	- C	
282		XDP=XPP-CL5
283		XRP=(XDP*DCDS(-BETA))-(YPP*DSIN(-BETA))
284		CXP=XRP+L5
285		CYP=(XOP*USIN(-BETA))+(YPP*DCOS(-BETA))
286		NL XP=C XP+C XX
287		NCYP=CYP+CYY
288		NCXP=CXP+CXX
289		NCYP=CYP+CYY
290		WRITE(6,200)P2,CXX,CYY,CRT
291	200	FURMAT(1H0,5x,F12.6,8x,F12.6,8X,F12.6)
292		IF(P2.E0.360.0) GO TO 1
293		GU TU 5
294	1	STOP
295		END

SENTRY

	GMTR	10
	GMT k	20
	GMTR	30
SUBROUTINE GMTRA	GMTR	40
	GMTR	50
PURPUSE	GMTR	60
TRANSPOSE A GENERAL MATRIX	GMTR	70
	GMTK	80
	GMTR	90
CALL GMTRA(A.R.N.M)	GMTR	100
	GMTR	110
DESCRIPTION OF PARAMETERS	GMTR	120
A - NAME UF MATRIX TO BE TRANSPOSED	GMTR	130
R - NAME OF RESULTANT MATKIX	GMTR	140
N - NUMBER OF RUWS OF A AND COLUMNS OF R	GMTR	1.50
M - NUMBER OF COLUMNS OF A AND ROWS OF R	GMTR	160
	GMTR	170
REMARKS	GMTR	180
MATRIX & CANNOT BE IN THE SAME ADCATION AS MATRIX A	GMTR	190
MATRICES A AND & MUST BE STURED AS GENERAL MATRICES	GMTR	200
	GMTR	210
SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED	GMTR	220
NONE	GMTR	230
	GMTR	240
METHOD	GMTR	250
TRANSPUSE N BY M MATRIX A TO FORM M BY N MATRIX R	GMTR	260
	GMTR	270
	GMTR	280
	GMTR	290
SUBROUTINE GMTRA(A,R,N,M)	GMTR	300
$DIMENSION(\mathbf{A}(1), R(1))$	GMTR	310
	GMTR	320
IR=0	GMTR	330
DO 10 I = 1.0	GMTR	340
I J = I - N	GMTR	350
DD 10 J≈1,M	GMTR	360
(+ L] = L	GMTR	370
1 R = 1 R + 1	GMTR	380
R(IR) = A(IJ)	GMTK	390
RETURN	GMTR	400
END	GMTR	410
	MPRD	10
	SUBROUTINE GMTRA PURPUSE TRANSPOSE A GENERAL MATRIX USAGE CALL GMTRA(A,R,N,M) DESCRIPTION OF PARAMETERS A - NAME OF PARAMETERS A - NAME OF RESULTANT MATKIX N - NUMBER OF RUNS OF A AND COLUMNS OF R M - NUMBER OF RUNS OF A AND RONS OF R REMARKS MATRIX R CANNOT BE IN THE SAME LOCATION AS MATRIX A MATRIX R CANNOT BE IN THE SAME LOCATION AS MATRIX A MATRICES A AND R MUST BE STORED AS GENERAL MATRICES SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED NONE METHOD TRANSPUSE N BY M MATRIX A TO FORM M BY N MATRIX R SUBROUTINE GMTRA(A,R,N,M) DIMENSION A(1),R(1) IR=0 DO 10 1=1,N 1J=1-N DO 10 J=1,M IJ=1AN IR=1R+1 R(IR)=A(1J) RETURN END	GMIK GMTK GMTK GMTR PURPUSE TRANSPOSE A GENERAL MATRIX USAGE CALL GMTRA(A,R,N,M) DESCRIPTION OF PARAMETERS A - NAME UF MATRIX TO BE TRANSPOSED GMTR R - NAME OF RASO F A AND COLUMNS OF R M - NUMBER OF CULUMNS OF A AND COLUMNS OF R M - NUMBER OF CULUMNS OF A AND COLUMNS OF R M - NUMBER OF CULUMNS OF A AND COLUMNS OF R M - NUMBER OF CULUMNS OF A AND COLUMNS OF R MATRIX R CANNOT BE IN THE SAME LOCATION AS MATRIX A GMTR MATRICES A AND F UNCTION SUBPROGRAMS REQUIRED GMTR MATRICES AND FUNCTION SUBPROGRAMS REQUIRED GMTR METHOD TRANSPUSE N BY M MATRIX A TO FORM M BY N MATRIX R SUBROUTINE GMTRA(A,R,N,M) DIMENSION A(1),R(1) IR=0 COLUMNS CMTR IR=0 CMTR IR=1N CMTR IR=1N CMTR GMTR CM

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	SUI DIN MS= IF(BROUTINI BROUTINI BROUTINI MENSION SPECIAI (MS-22)	M BY L THE RE INTO C FOLLOW RIX FOR A(1) E L CASE +MSB 30,10,	AND FUNC AND FUNC SULT IS COLUMN F NING TAE R ALL CO A GENERA GENERA GENERA SYMMET SYMMET DIAGON DIAGON DIAGON (A, B, R, N S(1), R(1) FOR DIA	TION BIS STOR PRODUC SLE SHI MBINA L L L RIC RIC RIC RIC RIC IAL IAL IAL IAL IAL IAL IAL	SUBPROU PREMUL ED IN 1 T- OWS THI TIONS (C C C C C C C C C C C C C C C C C C C	GRAMS REG LTIPLIED THE N BY E STORAGE JF INPUT B GENERAL SYMMETRIC DIAGONAL GENERAL SYMMETRIC DIAGONAL SYMMETRIC DIAGONAL	BY THE N L MATRIX MODE OF MATRICES	I BY M R. TH THE O GENERAI GENERAI GENERAI GENERAI GENERAI DIAGON	MATRI ISIS UTPUT L L L L L L	MPR MPR MPR MPR A MPR A MPR MPR MPR MPR MPR MPR MPR MPR MPR MPR	
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0	SUI DIN MS= IF(DJ	BROUTINI METHOD THE AND ROW THE MATI BROUTINI MENSION SPECIAI SPECIAI (MSA*10) (MS-22) 20 I= 1 I)=A(I)	TINES A M BY L THE RE INTO (FOLLOW RIX FOR A(1),E L CASE +MSB 30,10, N	AND FUNC AND FUNC AND FUNC SULT IS COLUMN F NING TAE R ALL CO A GENERA GENERA GENERA SYMMET DIAGON DIAGON DIAGON (A, B, R, N S(1), R(1) FOR DIA 30	TION BIS STOR PRODUC LE SHI MBINA L L RIC RIC RIC RIC AL JAL AL AL	SUBPROU PREMUI ED IN T T. OWS THI TIONS (C C C C C C C C C C C C C C C C C C C	GRAMS REG LTIPLIED THE N BY E STORAGE JF INPUT B GENERAL SYMMETRIC DIAGONAL GENERAL SYMMETRIC DIAGONAL 	AJIRED BY THE N L MATRIX MODE OF MATRICES	I BY M (R. TH THE D R GENERAL GENERAL GENERAL GENERAL GENERAL GENERAL OIAGON	MATRI ISIS UTPUT L L L L L L	MPR MPR MPR MPR MPR MPR MPR MPR MPR MPR	

	C C C	ALL UTHER CASES	MPRD MPRD MPRD	620 630 640
314 315 316	-	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	MPRD MPRD MPRD	650 660 670
317. 318		R(IR) = 0 (D1) 80 L=1,M	MPRD MPRD	680 690
319 320		IF(MS) 40,60,40 40 CALL LUC(J,I,IA,N,M,MSA)	MPRD MPRD	700 710
321 322		CALL LOU(I,K,IB,M,L,MSB) If (IA) 50,80,50	MPRD MPRD	720 730
323 324		50 IF(IB) 70,80,70 60 IA=N*(I−1)+J	MPRD MPRD	740 750
325		[H= M* (K−1)+1 70 R(IR)=R(IR)+A(IA)≠B(IH)	MPRD	760 770
327		80 CONTINUE	MPRD	780
328		YO IR=IR+L RETURN	MPRD	790 800
330		END	MPRD	810
	C		LUC	10
	с С	•••••••••••••••••••••••••••••••••••••••	LOC	20 30
	C	SUBROUTINE LOC		40
	C	PURPUSE	LOC	60
	C	SPECIFIED STORAGE MODE	LUC	80
	С С	USAGE	L 0C	90 100
	č	CALL LOC (I,J,IR,N,M,MS)	LOC	110
	c	DESCRIPTION OF PARAMETERS	LOC	120 130
	ί C	I - ROW NUMBER OF ELEMENT	LOC	140
	č	IR - RESULTANT VECTOR SUBSCRIPT	LOC	160
	C C	N – NUMBER OF ROWS IN MATRIX M – NJMBER OF COLUMNS IN MATRIX	LOC	170 180
•	C	MS - ONE DIGIT NUMBER FOR STORAGE MODE OF MATRIX		190
	č	1 - SYMMETRIC	LOC	210
	C	2 - DIAGUNAL	LOC	220
	C	REMARKS	LOC	240
<i>p</i> .	č		LOC	260
	ι C	NONE	LOC	270 280
	C	METHOD		290 300
	č	MS=0 SUBSCRIPT IS COMPUTED FOR A MATRIX WITH N*M ELEMENTS	LOC	310
	C	IN STURAGE (GENERAL MATRIX) MS=1 SUBSCRIPT IS COMPUTED FOR A MATRIX WITH N*(N+1)/2 IN	L0C L0C	320 330
	C C	STURAGE (UPPER TRIANGLE OF SYMMETRIC MATRIX). IF		340
	č	CURRESPONDING ELEMENT IN UPPER TRIANGLE.	LOC	360
	С С	MS=2 SUBSCRIPT IS COMPUTED FOR A MATRIX WITH N ELEMENTS IN STORAGE (DIAGONAL ELEMENTS OF DIAGONAL MATRIX).	LOC	370 380
	C	IF ELEMENT IS NOT ON DIAGONAL (AND THEREFORE NOT IN	LOC	390

	C	STORAGE	IR IS SET TO ZER	Ú.	LOC	400
	С				LOC	410
	C				LOC	: 420
	С				LUC	430
331		SUBROUTINE LUCII, J, IR	N M M MS		LOC	440
	C			i de la composición d	LOC	450
332		I X = I			LOC	460
333		JX = J			LOC	470
334		1+(MS-1) 10,20,30			LOC	480
335	- 1	0 1RX=N*(JX-L)+[X			LOC	490
336		GO TO 36	*		LOC	500
337	2	0 IF(IX-JX) 22,24,24			LOC	510
338	2	2 1KX=IX+(JX*JX-JX)/2			LOC	520
339		GO TO 36			LOC	530
340	2	4 IRX=JX+(IX*IX-IX)/2			LOC	540
341		GU TO 36			LOO	550
342	3	0 IRX=0			LOC	560
343		[F(IX-JX) 36,32,36			LOC	570
344	د	2 1RX=1X			LOC	580
345	3	6 [R= IRX			LOC	590
346		RETURN			LOC	600
347		END			LOC	610

APPENDIX D

CASE III: DISTRIBUTED MASS MODEL

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FORTRAN IV G1 RELEASE 2.0 MAIN DATE = 7707420/14/13 C **** **** Ĺ C C * CASE III С С ----C * C * C * C DISTRIBUTED MASS MODEL С * C. * -----С ¢ OF С ĉ * THE SUURCE FOUR-BAR MECHANISM С * С ¢, Ú * ί ***** С ******* ***** ι С ***SUBROUTINE MPRD** C ι * с. С **** С * . . . С *** PURPUSE** Ċ. С * С * MULTIPLY TWO MATRICES TO FORM A RESULTANT MATRIX. С *..... С ***USAGE** C Ú. * Ċ * CALL MPRD(A,B,R,N,M,MSA,MSB,L) С *. **#DESCRIPTION** Ĺ C * A-NAME OF FIRST MATRIX. A-NAME OF FIRST MATRIX. B-NAME OF SECOND MATRIX. R-NAME OF OUTPUT MATRIX. N-NUMBER OF ROWS IN A AND R. M-NUMBER OF COLUMNS IN A AND ROWS IN B. С * ¢ ί С * С * * MSA-JNE DIGIT NUMBER FOR STORAGE MODE OF MATRIX A. L C * O-GENERAL. 1-SYMMETRICAL . С * Č * 2-DIAGONAL. C * MSB- SAME AS MSA EXCEPT FOR MATRIX B. С * L-NUMBER OF CULUMNS IN B AND R. С C * *DATA C. Ċ * **≭GENERAL** C TAKES COLUMN WISE C, * С * *DIAGONAL C Č * DIAGONAL COLUMN WISE

C SYMMETRICAL C COLUMN WISE C COLUMN WISE C C C C C C C C C C C C C C C C C C C	FORTRAN IV GI R	ELEASE 2.0	MAIN	DATE = 77074	20/14/13
		C *			*
C * CLUWN WISE C *CEMARKS C *CEMARKS C *CEMARKS C * MATRIX & CANNOT BE IN THE SAME LDCATION AS MATRIX A OR B. NUMBER UF COLUMNS OF MATRIX A MUST BE EQUAL TO NUMBER OF ROWS C * SUBROUTINES AND SUBPROGRAMS REQUIRED C *SUBROUTINES AND SUBPROGRAMS REQUIRED C * COLOC C *		Ú *SYMMETRICA	AL		*
C *REMARKS C *REMARKS C *REMARKS C *ATKIX Å CANNUT BE IN THE SAME LOCATION AS MATRIX A OR B. NUMBER OF COLUMNS OF MATRIX A MUST BE EQUAL TO NUMBER OF ROWS C UF MATRIX H. C *SUBROUTINES AND SUBPROGRAMS REQUIRED C LOC C * THE H BY L MATRIX B IS PRE-MULTIPLIED BY THE N BY M MATRIX A C * AND THE KESULT IS STORED IN THE N BY L MATRIX A. THIS IS A RUW C * IN TO COLUMN PRODUCT. C * THE FOLLOWING TABLE SHOWS THE STORAGE MODE OF THE OUTPUT C * MATRIX FJH ALL CUMBINATIONS OF INPUT MATRICES. C * GENERAL SYMMETRICAL GENERAL C * GENERAL SYMMETRICAL GENERAL C * GENERAL SYMMETRICAL GENERAL C * SYMMETRICAL GENERAL C * SYMMETRICAL GENERAL C * DIAGONAL SYMMETRICAL GENERAL C * DIAGONAL SYMMETRICAL GENERAL C * DIAGONAL UIAGONAL DIAGONAL C * DIAGONAL UIAGONAL C * OIAGONAL SYMMETRICAL GENERAL C * DIAGONAL UIAGONAL C * OIAGONAL SYMMETRICAL GENERAL C * OIAGONAL SYMMETRICAL GENERAL C * OIAGONAL SYMMETRICAL GENERAL C * OIAGONAL UIAGONAL C * OIAGONAL * * * * * * * * * * * * * * * * * * *		C * COLUMN	WISE		*
C PKEMARKS C MATRIX & CANNOT BE IN THE SAME LOCATION AS MATRIX A OR B. NUMBER OF COLUMNS OF MATRIX A MUST BE EQUAL TO NUMBER OF ROWS C WHETHOD C SUBROUTINES AND SUBPRUGRAMS REQUIRED C LOC C METHOD C METHOD C THE M BY L MATRIX B IS PRE-MULTIPLIED BY THE N BY M MATRIX A AND THE RESULT IS STORE IN THE N BY L MATRIX R. THIS IS A RUW C IN TO COLUMN PRODUCT. C THE FOLLOWING TABLE SHOWS THE STORAGE MODE OF THF OUTPUT C MATRIX FJK ALL CUMBINATIONS OF INPUT MATRICES. C C A B R C O GENERAL GENERAL GENERAL C UENERAL SYMMETRICAL GENERAL C SYMMETRICAL GENERAL C SYMMETRICAL GENERAL C SYMMETRICAL GENERAL C SYMMETRICAL GENERAL C O IAGONAL SYMETRICAL GENERAL C O IAGONAL SYMETRICAL GENERAL C O IAGONAL SYMETRICAL GENERAL C O IAGONAL SYMETRICAL C ALL DIFFER CASES C O 0003 MESTIGNESS C O 0004 16 (MS -22) 30,10,30 10 U 20 1=1,N 0014 00 90 J=1,N 0015 C ALL DIFFER CASES C O 0005 0017 00 00 J=1,N 0014 00 90 J=1,N 0014 00 90 J=1,N 0015 C ALL LOCIT,F,B,M,L,MSB) 0015 0015 0017 0018 C O IAENNESS C O 0018 C O IAENNESS C O 0019 0010 0014 C ALL LOCIT,F,B,M,L,MSB) 0015 0014 C ALL LOCIT,F,B,M,L,MSB) 0015 0015 0016 C ALL LOCIT,F,B,M,L,MSB) 0016 C ALL LOCIT,F,B,M,L,MSB) 0017 C ALL LOCIT,F,B,M,L,MSB) 0018 C ALL DOCING,F,C C ALL DOCI		· C * • • • • • • • • •			*
C PREMARKS C MATRIX & CANNOT BE IN THE SAME LOCATION AS MATRIX A OR B. MATRIX B. C MATRIX B. C UF MATRIX B. C UF MATRIX B. C UF MATRIX B. C SUBBROUTINES AND SUBPROGRAMS REQUIRED C LOC C LOC C HE HOD C HE HOD C THE H BY L MATRIX B IS PRE-MULTIPLIED BY THE N BY M MATRIX A C AND THE RESULT IS STORED IN THE N BY L MATRIX A. THIS IS A RUM C IN TU COLUMN PRODUCT. C THE FOLLOWIN PRODUCT. C THE FOLLOWING TABLE SHOWS THE STORAGE MODE OF THE OUTPUT C MATRIX FAR ALL COMBINATIONS OF INPUT MATRIXES. C G GENERAL GENERAL GENERAL C G GENERAL SYMMETRICAL GENERAL C SYMMETRICAL GENERAL GENERAL C SYMMETRICAL GENERAL C SYMMETRICAL GENERAL C SYMMETRICAL GENERAL C O DIAGONAL SYMMETRICAL GENERAL C O DIAGONAL SYMMETRICAL GENERAL C O DIAGONAL DIAGONAL GENERAL C O DIAGONAL DIAGONAL OIAGONAL C SUBMOUTINE MERO(A,B,R,N,M,NSA,MSB,L) DIAGONAL DIAGONAL OIAGONAL C ALL DIHER (CASES C ALL DIHER (CASES C C C CALL COLLIN, N, M, NSA, MSB,L) DIAGONAL FIELAN C C C C C CALL DIAGONAL C C C C C C C C C C C C C C C C C C C		C *			*
C WATRIX & CANNOT BE IN THE SAME LUCATION AS MATRIX A OR B. NUMBER OF COLUMNS OF MATRIX A MUST BE EQUAL TO NUMBER OF ROWS C WF MATRIX B. C SUBROUTINES AND SUBPROGRAMS REQUIRED C LOC WHETHOD C THE M BY L MATRIX B IS PRE-MULTIPLIED BY THE N BY H MATRIX A AND THE RESULT IS STORED IN THE N BY L MATRIX R. THIS IS A ROW C IN TO COLUMN PRODUCT. C THE FOLLOWING TABLE SHOWS THE STORAGE MODE OF THE OUTPUT C MATRIX FJK ALL CUMBINATIONS OF INPUT MATRICES. C G A B R C GENERAL GENERAL GENERAL C GENERAL SYMMETRICAL GENERAL C GENERAL SYMMETRICAL GENERAL C SYMMETRICAL STANDAL GENERAL C SYMMETRICAL SYMMETRICAL GENERAL C DIAGONAL JACONNEL DIAGONAL C ALL DIFLEXION ALCOND DIFLEXION ALZOOD JELZOOD J DIFLEXION ALZOOD J DIFLEXION ALZOOD JELZOOD J DIFLEXION ALZOOD J DIFLEXION ALZOOD J C ALL DIFLEX C ALL OTHER CASES C C ALL OTHER CASES C C ALL OTHER CASES C C ALL OTHER CASES C C C ALL OTHER CASES C C C CALL DIFLEX CONDICIES C C CALL OTHER CASES C C CALL CLISTIN MENDING C C CALL OTHER CASES C C CALL CLISTIN MENDING C C C C C C C C C C C C C C C C C C C		C *REMARKS			*
L • MATRIX R (CANNOT BE IN THE SAME LUCATION XA MATRIX A OR B. C • UUF MATRIX B. C • UF MATRIX B. C • UUF MATRIX B. C • UUT OUT MATRIX C. C • UUT OUT MATRIX C.		C *			*
C • NUMBER OF COLUMNS OF MATRIX A MUST BE EQUAL TO NUMBER OF ROWS • C • UF MATRIX B. C • SUBROUTINES AND SUBPRUGRAMS REQUIRED C • SUBROUTINES AND SUBPRUGRAMS REQUIRED C • LOC C • LOC C • C • C • C • C • C • C • C • C • C •		L * MATRIX	R CANNUT BE IN THE	SAME LOCATION AS MATE	RIX A OR B. *
C + UF MATRIX B- C + SUBROUTINES AND SUBPRUGRAMS REQUIRED C + SUBROUTINES AND SUBPRUGRAMS REQUIRED C + C + C + C + C + C + C + C + C + C +		C ¥ NUMBER	OF COLUMNS OF MATE	IX A MUST BE EQUAL TO	NUMBER OF ROWS *
C SUBROUTINES AND SUBPROGRAMS REQUIRED C LOC C LOC C HETHOD C THE M BY L MATRIX B IS PRE-MULTIPLIED BY THE N BY M MATRIX A C AND THE RESULT IS STORED IN THE N BY L MATRIX R. THIS IS A ROW C THE FOLLOWING TABLE SHOWS THE STORAGE MODE OF THE OUTPUT C THE FOLLOWING TABLE SHOWS THE STORAGE MODE OF THE OUTPUT C MATRIX FOR ALL CUMBINATIONS OF INPUT MATRICES. C GENERAL GENERAL C GENERAL SYMMETRICAL C GENERAL DIAGONAL C SYMMETRICAL SENERAL C GENERAL GENERAL C SYMMETRICAL GENERAL C SYMMETRICAL GENERAL C SYMMETRICAL GENERAL C SYMMETRICAL GENERAL C DIAGONAL SYMMETRICAL C DIAGONAL		C * OF MAT	RIX B.		*
C *SUBROUTINES AND SUBPROGRAMS REQUIRED C * C * C * C * C * C * C * THE H BY L MATRIX B IS PRE-MULTIPLIED BY THE N BY M MATRIX A C * C		C *	• • • • • • • • • • • • • • • • • • • •		• • • • • • • • • • • • • • • • • • *
L LU. C + HETHOD C + HETHOD C + HETHOD C + THE M BY L MATRIX B IS PRE-MULTIPLIED BY THE N BY M MATRIX A AND THE RESULT IS STORED IN THE N BY L MATRIX R. THIS IS A RDW C + IN TU COLUMN PRODUCT. C + THE FOLLOWING TABLE SHOWS THE STORAGE MODE OF THE DUTPUT C + MATRIX FDR ALL CUMBINATIONS OF INPUT MATRICES. C + A B R C + GENERAL GENERAL GENERAL GENERAL C + GENERAL SYMMETRICAL GENERAL C + GENERAL SYMMETRICAL GENERAL C + GENERAL DIAGONAL GENERAL C + GENERAL SYMMETRICAL GENERAL C + GENERAL BIAGONAL GENERAL C + JIAGONAL GENERAL GENERAL C + JIAGONAL JIAGONAL GENERAL C + JIAGONAL JIAGONAL JIAGONAL C + JIAGONAL JIAGONAL DIAGONAL C + JIAGONAL JIAGONAL DIAGONAL C + JIAGONAL SYMMETRICAL GENERAL * C + JIAGONAL JIAGONAL DIAGONAL C + JIAGONAL JIAGONAL DIAGONAL C + JIAGONAL SYMMETRICAL GENERAL * C + JIAGONAL JIAGONAL DIAGONAL C + JIAGONAL JIAGONAL DIAGONAL 0001 JI HEMSION AL2000J, RI2000J, RI2000J D POU 20 1=1, N 0002 D 00 K + 1, L 0003 HEMS 10 METIN C + LUC (J, 1, 1, 1, N, M, MSA) 0014 HO 00 J = 1, N 11 (MS + 0, 0, 0, 0) 00 J = 1, N 0015 CALL LUC (I, K, 1B, M, L, MSB) 0016 D 00 J = 1, N 11 (MS + 0, 0, 0, 0) 0017 SO FILIS / 0, 0, 0, 0 0018 GO 14 LUC (J, 1, 1, 1, N, M, MSA) 0015 CALL LUC (I, K, 1B, M, L, MSB) 0016 D 00 J = 1, N 11 (MS + 0, 0, 0, 0, 0) 0017 SO FILIS / 0, 0, 0, 0 0018 GO 1A HE (L) (J, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,		C #SUBROUTIN	ES AND SUBPROGRAMS	REQUIRED	*
0008 10 2		L ¥ LUC			*
C *METHOD C THE M BY L MATRIX B IS PRE-MULTIPLIED BY THE N BY M MATRIX A C AND THE RESULT IS STORED IN THE N BY L MATRIX R. THIS IS A RDW C IN TO COLUMN PRUDUCT. C THE FOLLOWING TABLE SHOWS THE STORAGE MODE OF THE OUTPUT C MATRIX FJR ALL CUMBINATIONS OF INPUT MATRICES. C MATRIX FJR ALL CUMBINATIONS OF INPUT MATRICES. C GENERAL C SYMMETRICAL C DIAGONAL C DIAGONAL <t< td=""><td></td><td>د *•••••••</td><td>• • • • • • • • • • • • • • • • • • • •</td><td>• • • • • • • • • • • • • • • • • • • •</td><td>••••••</td></t<>		د *•••••• •	• • • • • • • • • • • • • • • • • • • •	• • • • • • • • • • • • • • • • • • • •	••••••
C + THE H BY L MATRIX B IS PRE-HULT IPLIED BY THE N BY M MATRIX A C + THE M BY L MATRIX B IS PRE-HULT IPLIED BY THE N BY M MATRIX A. C + THE FOLLOWING TABLE SHOWS THE N BY L MATRIX R. THIS IS A ROWE C + THE FOLLOWING TABLE SHOWS THE STORAGE MODE OF THE OUTPUT C + MATRIX FOR ALL COMBINATIONS OF INPUT MATRICES. C + A B R C + A B R C + C + GENERAL GENERAL GENERAL * C + GENERAL SYMMETRICAL GENERAL * C + GENERAL DIAGONAL GENERAL * C + SYMMETRICAL DIAGONAL GENERAL * C + SYMMETRICAL DIAGONAL GENERAL * C + DIAGONAL GENERAL * C + DIAGONAL SYMMETRICAL GENERAL * C + DIAGONAL SYMMETRICAL GENERAL * C + DIAGONAL UIAGONAL GENERAL * C + DIAGONAL SYMMETRICAL GENERAL * C + DIAGONAL UIAGONAL BENERAL * C + DIAGONAL UIAGONAL BENERAL * C + DIAGONAL UIAGONAL BENERAL * C + DIAGONAL UIAGONAL * C * THE PRON * C * C + CASES * C * C + CALL COCI, *, 1A, N, M, MSA) * C * C + CALL COCI, *, 1A, N, M, MSA) * C * C + CASES * C * C + CALL COCI, *, 1A, N, M, MSA) * C * C + CALL COCI, *, 1A, N, M, MSA) * C * C + CALL COCI, *, 1A, N, M, MSA) * C * C + CALL COCI, *, 1A, N, M, MSA) * C * C + CALL COCI, *, 1A, N, M, MSA) * C * C + CALL COCI, *, 1A, N, M, MSA) * C * C + CALL COCI, *, 1A, N, M, MSA) * C * C + CALL COCI, *, 1A, N, M, MSA) * C * C + CALL COCI, *, 1A, N, M, MSA) * C * C + CALL COCI, *, 1A, N, M, MSA * C * C + CALL COCI, *, 1A, N, M, MSA * C * C + CASE * C * C + CALL COCI, *, 1A, N, M, MSA * C * C + CALL COCI, *, 1A, N, M, MSA * C * C + CALL COCI, *, 1A, N, M, MSA * C * C + CALL COCI, *, 1A, N, M, MSA * C * C + CALL COCI *		L + C + MC T⊔/DD			*
0008 0008 0008 0008 0008 0008 0008 0008 0008 0008 0008 000000000000000000000000000000000000					
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C ALL DTHER CASES C C C CALL DCI (1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1		-C + AND ΠΩ Γ' 34 ΙΝΤΩΩ	CILIMN PRIDUCT	IN THE N DT C MAIRIA I	X. 1813 IS A KUW≁
0001 * THE FOLLOWING TABLE SHOWS THE STORAGE MODE OF THE OUTPUT 0 * MATRIX FJR ALL CUMBINATIONS OF INPUT MATRICES. 0 *		- C * 111100	COLONNE PRODUCT.		*
C * MATRIX FJK ALL COMBINATIONS OF INPUT MATRICES. C * C * C * C * C * C * C * C * C * C *		C .* THE FO	LOWING TABLE SHOWS	THE STORAGE MODE OF T	СНЕ ПИТРИТ 👘 🔭
C * A B R * C * GENERAL GENERAL GENERAL * C * GENERAL SYMMETRICAL GENERAL * C * GENERAL JIAGONAL GENERAL * C * SYMMETRICAL DIAGONAL GENERAL * C * SYMMETRICAL GENERAL GENERAL * C * SYMMETRICAL GENERAL GENERAL * C * DIAGONAL GENERAL GENERAL * C * DIAGONAL SYMMETRICAL GENERAL * C * DIAGONAL DIAGUNAL DIAGONAL * C * DIAGONAL SYMMETRICAL GENERAL * C * DIAGONAL SYMMETRICAL GENERAL * C * DIAGONAL SYMMETRICAL GENERAL * C * DIAGONAL SYMETRICAL SYMETRICAL * C * DIAGONAL SYMETRICAL * C *		C * MATRIX	FOR ALL COMBINATION	NS OF INPUT MATRICES.	*
C * A B R * C * GENERAL GENERAL GENERAL GENERAL * C * GENERAL SYMMETRICAL GENERAL * C * GENERAL DIAGONAL GENERAL * C * SYMMETRICAL DIAGONAL GENERAL * C * SYMMETRICAL GENERAL GENERAL * C * SYMMETRICAL GENERAL GENERAL * C * SYMMETRICAL GENERAL GENERAL * C * DIAGONAL GENERAL GENERAL * C * DIAGONAL SYMMETRICAL GENERAL * C * DIAGONAL SYMMETRICAL GENERAL * O001 SUBRUUTINE MPRD(A, B,R, N, M, M SA, MSB,L) DIAGONAL * 0002 C SPELIAL CASE FUR DIAGONAL DIAGONAL * 0003 MS=MSA*IO-MSB - - - - 0004 I+(MS-22) 30,10,30 - - - - 0005 ID 20 I=1,N - - - - 0		C * .			*
C * GENERAL GENERAL GENERAL GENERAL GENERAL GENERAL SYMMETRICAL GENERAL * C * GENERAL SYMMETRICAL DIAGONAL GENERAL * C * SYMMETRICAL DIAGONAL GENERAL * C * SYMMETRICAL DIAGONAL GENERAL * C * SYMMETRICAL GENERAL GENERAL * C * SYMMETRICAL GENERAL GENERAL * C * DIAGONAL GENERAL GENERAL * C * DIAGONAL GENERAL GENERAL * 0001 SUBRUDTINE MERDIA, B, R, N, M, M SA, MSB, L) DIAGONAL DIAGONAL DIAGONAL DIAGONAL MS 0002 DIAGONAL GENERAL SUBRUDTINE MERDIA, B, R, N, M, M SA, MSB, L) DIAGONAL DIAGONAL MS 0003 MS=MSA*10+MSB DIAGONAL MS=MSA*10+MSB MS MS 0004 INFINALIZASE GENERAL * GENERAL * GENERAL * </td <td></td> <td>č *</td> <td>Α</td> <td>В</td> <td>R *</td>		č *	Α	В	R *
C * GENERAL GENERAL GENERAL GENERAL * C * GENERAL DIAGONAL GENERAL * C * GENERAL DIAGONAL GENERAL * C * SYMMETRICAL DIAGONAL GENERAL * C * SYMMETRICAL SYMMETRICAL GENERAL * C * SYMMETRICAL SYMMETRICAL GENERAL * C * DIAGONAL SYMMETRICAL GENERAL * C * DIAGONAL SYMMETRICAL GENERAL * C * DIAGONAL SYMMETRICAL GENERAL * 0001 SUBROUTINE MPROIA.B,R.N.M. MASA.MSB,L) OIAGONAL * * * 0002 DIMENSION A(2000).R(2000).R(2000) R * * * * 0003 MS=SASA*10 MAS2 * * * * * * * 0004 IF (MS-22) 30,10,30 * * * * * * * <td< td=""><td></td><td>- Č +</td><td></td><td></td><td>*</td></td<>		- Č +			*
C * GENERAL SYMMETRICAL GENERAL * C * GENERAL DIAGONAL GENERAL * C * SYMMETRICAL DIAGONAL GENERAL * C * SYMMETRICAL GENERAL GENERAL * C * DIAGONAL UIAGONAL DIAGONAL * C * DIAGONAL UIAGONAL DIAGONAL * C * DIAGONAL UIAGONAL DIAGONAL * C * DIAGONAL UIAGONAL * C * DIAGONAL SYMMETRICAL GENERAL * C * DIAGONAL UIAGONAL * C * DIAGONAL SYMMETRICAL GENERAL * C * DIAGONAL UIAGONAL * C * DIAGONAL * C * C * C * C * C * C * C * C		(, *	GENER AL	G EN ER AL	GENERAL *
C * GENERAL 01AGONAL GENERAL * C * SYMMETRICAL DIAGONAL GENERAL * C * SYMMETRICAL GENERAL GENERAL * C * SYMMETRICAL SYMETRICAL GENERAL * C * DIAGONAL UIAGONAL DIAGONAL DIAGONAL DIAGONAL DIAGONAL SYMETRICAL GENERAL * 0001 SUBROUTINE MPELIA SASENT DIAGONAL DIAGONAL DIAGONAL SUBROUTINE SUBROUTINE SUBROUTINE SUBROUTINE SUBROUTINE SUBROUTINE SUB		C *	GENERAL	SYMMETRICAL	GENERAL *
C * SYMMETRICAL DIAGONAL GENERAL * C * SYMMETRICAL GENERAL GENERAL * C * DIAGONAL GENERAL GENERAL * C * DIAGONAL GENERAL GENERAL * C * DIAGONAL SYMMETRICAL GENERAL * C * DIAGONAL SYMMETRICAL GENERAL * C * DIAGONAL SYMMETRICAL GENERAL * 0001 SUBROUTINE MPRDIA, B, N, M, MSA, MSB, LI DIAGONAL UIAGONAL VIAGONAL * 0002 DIMENSION AI2000J, BI2000J, R(2000) C SPELIAL CASE FUR DIAGONAL UIAGONAL * * 0003 MS=MSA*I0+MSB MS=MSA*I0+MSB *		C 🔹	GENERAL	DIAGONAL	GENERAL *
C * SYMMETRICAL GENERAL GENERAL * C * SYMMETRICAL SYMMETRICAL GENERAL * C * DIAGONAL GENERAL GENERAL * C * DIAGONAL SYMMETRICAL GENERAL * C * DIAGONAL UIAGONAL DIAGONAL DIAGONAL O001 DIMENSION A(2000), B(2000), R(2000) * * * * O003 # * SUBROUTINE * * *		C * ,	SYMMETRICAL	DIAGONAL	GENERAL *
C * SYMMETRICAL SYMMETRICAL GENERAL * C * DIAGONAL GENERAL GENERAL * C * DIAGONAL SYMMETRICAL GENERAL * C * DIAGONAL UIAGONAL DIAGONAL DIAGONAL SYMMETRICAL GENERAL * 0001 SUBROUTINE MPROIA.B.R.N.M., MS.A.MSB.L) DIAGONAL VIAGONAL * <t< td=""><td></td><td>C *</td><td>SYMMETRICAL</td><td>GENERAL</td><td>GENERAL *</td></t<>		C *	SYMMETRICAL	GENERAL	GENERAL *
L * DIAGONAL GENERAL GENERAL * L C * DIAGONAL SYMMETRICAL GENERAL * C * DIAGONAL UIAGONAL DIAGONAL * 0001 SUBROUTINE MPROIA, B, R, N, M, MSA, MSB, L) DIAGONAL * * 0002 DIMENSION A(2000), B(2000), R(2000) * * * 0003 C SPELIAL CASE FUR DIAGONAL * * * 0004 I+(MS-22) 30,10,30 * * * * 0006 20 R(I)=A(1)*B(I) * * * * * 0006 20 R(I)=A(1)*B(I) *		С 🔹 🕺	SYMMETRICAL	SYMME TRICAL	GENERAL *
C * DIAGONAL SYMMETRICAL GENERAL * C * DIAGONAL UIAGUNAL UIAGONAL * 0001 SUBROUTINE MPRD(A,B,R,N,M,MSA,MSB,L) DIAGONAL * 0002 DIMENSION A(2000),R(2000),R(2000) * * 0003 MS=MSA*10+MSB * * * 0004 I+(MS-22) 30,I0,30 * * * 0005 IO OU 20 I=I,N * * * 0006 20 K(I)=A(I)*B(I) * * * * 0007 RETURN * * * * 0010 D0 90 J=1,N * * * * 0011 R(IR)=0 * * * * 0012 DU 30 I=I,N * * * * 0010 D0 90 J=1,N * * * * 0012 D0 30 IF=1 * * * * 0013 IF(MS) 40,60,40 * * * 0014 40 CALL LUC(J,I,IA,N,M,MSA) * * * * 0015 CALL LUC(I,K,KB,M,L,MSB) * * * *		C 🔹	DIAGONAL	GENERAL	GENERAL *
C * DIAGONAL DIAGONAL DIAGONAL * 0001 SUBROUTINE MPRD(A, B, R, N, M, M SA, MSB, L) 0002 DIMENSION A(2000), B(2000), R(2000) *		C *	DIAGONAL	SYMMETRICAL	GENERAL *
0001 SUBROUTINE MPRD(A, B,R, N, M, MSA, MSB, L) 0002 DIMENSION A(2000), B(2000), R(2000) 003 MS=MSA*104MSB 0004 114 (MS-22) 30,10,30 0005 10 DU 20 I=1,N 0007 RETURN 0009 00 (KI)=A(I)*B(I) 0009 00 S=1,N 0010 00 90 K=1,L 0011 R(IR=1 0012 DU 30 I=1,N 0013 IF(MS) 40,60,40 0014 40 CALL LUC(J,I,IA,N,M,MSA) 0015 CALL LUC(I,K,IB,M,L,MSB) 0016 IF(IA) 50,80,50 0017 50 IF(IB) 70,80,70 0018 60 IA=N*(I-1)+J		C *	DIAGONAL	DIAGONAL	DIAGONAL *
0001 SUBROUTINE MPRD(A,B,K,N,M,MSA,MSB,L) 0002 DIMENSION A(2000), B(2000), R(2000) 003 MS=MSA*10+MSB 0004 I+(MS-22) 30,10,30 0005 I0 DU 20 I=1,N 0006 20 R(I)=A(I)*B(I) 0007 RETURN C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C O010 D0 90 J=1,N 0011 R(IR)=0 0012 D0 60 I=1,M 0013 IF(MS) 40,60,40 0014 40 CALL LUC(J,I,IA,N,M,MSA) 0015 CALL LUC(J,I,IA,N,M,MSA) 0016 IF(IA) 50,60,50 017 50 IF(IB) 70,80,70			****	******	** ** * * * * * * * * * * * * * * * *
0002 C SPELIAL CASE FUR DIAGONAL 0003 MS=MSA*10+MSB 0004 1+(MS-22) 30,10,30 0005 10 DU 20 I=1,N 0006 20 R(I)=A(I)+B(I) 0007 RETURN C ALL DIHER CASES C ALL DIHER CASES C C 0010 D0 90 K=1,L 00011 R(IR)=0 0012 D0 30 I=1,N 0013 IF(MS) 40,60,40 0014 40 CALL LUC(I,K,IB,M,L,MSB) 0015 CALL LUC(I,K,IB,M,L,MSB) 0016 IF(IB) 70,80,70 0018 60 IA=N*(I-1)+J	0001	SUBROUTIN	E MPRULA, B,R, N, M, MS	A, MSB, LJ	
0003 MS=MSA*I0+MSB 0004 IF(MS-22) 30,10,30 0005 I0 DU 20 I=1,N 0006 20 K(I)=A(I)*B(I) 0007 RETURN C ALL DTHER CASES C C 0009 D0 90 K=1,L 0010 D0 90 J=1,N 0011 R(IR)=0 0012 D0 80 I=1,M 0013 IF(MS) 40,60,40 0014 40 CALL LUC(J,I,IA,N,M,MSA) 0015 CALL LUC(I,K,IB,M,L,MSB) 0016 IF(IA) 50,80,70 0018 60 IA=N*(I-1)+J	0002		ALZUUUJ, BLZUUUJ, KL	20001	
0003 14 (MS-22) 30,10,30 0004 14 (MS-22) 30,10,30 0006 20 R(1)=A(1)*B(1) 0007 RETURN C ALL DTHER CASES C C 0008 30 1R=1 0009 D0 90 K=1,L 0010 D0 90 J=1,N 0011 R(1R)=0 0012 DU 80 I=1,M 0013 IF(MS) 40,60,40 0014 40 CALL LUC(J,I,IA,N,M,MSA) 0015 CALL LUC(I,K,IB,M,L,MSB) 0016 IF(1B) 70,80,70 0018 G0 IA=N*(I-1)+J	0003		ASE FOR DIAGONAL		
0005 10 DU 20 I=1.N 0006 20 R(I)=A(I)*B(I) 0007 RETURN C C C ALL DTHER CASES C C 0009 DU 90 K=1.L 0010 DU 90 J=1.N 0011 R(IR)=0 0012 DU 80 I=1.M 0013 IF(MS) 40.60.40 0014 40 CALL LUC(I,K,IB,M,L,MSB) 0015 CALL LUC(I,K,IB,M,L,MSB) 0016 IF(IB) 70.80.70 0018 G0 IA=N*(I-1)+J	0004	1E(MS=22)	30.10.30		
0006 20 R(I)=A(I)*B(I) 0007 RETURN C C C ALL DTHER CASES C 0009 D0 90 K=1,L 0010 D0 90 J=1,N 0011 R(IR)=0 0012 D0 30 I=1,M 0013 IF(MS) 40.60.40 0014 40 CALL LUC(I,K,IB,M,L,MSB) 0015 CALL LUC(I,K,IB,M,L,MSB) 0016 IF(IB) 70.80.70 0018 60 IA=N*(I-1)+J	0005	10 00 20 1=1	-N		
0007 RETURN C ALL DTHER CASES C O008 30 IR=1 0009 D0 90 J=1.N 0010 D0 90 J=1.N 0011 R(IR)=0 0012 D0 80 I=1.M 0013 IF(MS) 40.60.40 0014 40 CALL LUC(J.I.IA.N.M.MSA) 0015 CALL LUC(I.K.IB.M.L.MSB) 0016 IF(IB) 70.80.70 0018 G0 IA=N*(I-1)+J	0006	20 R(1) = A(1)	¢Η(Ε)		
C ALL DIHER CASES C ALL DIHER CASES C BO IR=1 0009 D0 90 J=1.N 0010 D0 90 J=1.N 0011 R(IR)=0 0012 D0 80 I=1.M 0013 IF(MS) 40.60.40 0014 40 CALL LUC(I.K.IB.M.L.MSB) 0015 CALL LUC(I.K.IB.M.L.MSB) 0016 IF(IB) 70.80.70 0018 G0 IA=N*(I-1)+J	0007	RETURN			
C ALL DTHER CASES C C 0009 D0 90 K=1,L 0010 D0 90 J=1,N 0011 R(1R)=0 0012 D0 80 I=1,M 0013 IF(MS) 40,60,40 0014 40 CALL LUC(J,I,IA,N,M,MSA) 0015 CALL LUC(I,K,IB,M,L,MSB) 0016 IF(1A) 50,80,50 0017 50 IF(1B) 70,80,70 0018 60 IA=N*(I-1)+J	••••	6			
C 0008 30 IR=1 0009 D0 90 K=1,L 0010 D0 90 J=1,N 0011 R(IR)=0 0012 D0 80 I=1,M 0013 IF(MS) 40,60,40 0014 40 CALL LUC(J,I,IA,N,M,MSA) 0015 CALL LUC(I,K,IB,M,L,MSB) 0016 IF(IB) 70,80,70 0018 G0 IA=N*(I-1)+J		C ALL DITHER	CASES		
0008 30 IR=1 0009 D(1 90 K=1,L 0010 D(1 90 J=1,N 0011 R(IR)=0 0012 D0 80 I=1,M 0013 IF(MS) 40,60,40 0014 40 CALL LUC(J,I,IA,N,M,MSA) 0015 CALL LUC(I,K,IB,M,L,MSB) 0016 IF(IB) 70,80,70 0018 60 IA=N*(I-1)+J		C .			
0009 D(1 90 K= 1, L * 0010 D(1 90 J= 1, N * 0011 R(1R)=0 * 0012 D0 80 I= 1, M * 0013 IF(MS) 40,60,40 * 0014 40 CALL LUC(J,I,IA,N,M,MSA) * 0015 CALL LUC(I,K,IB,M,L,MSB) * 0016 IF(1A) 50,80,50 * 0018 60 IA=N*(I-1)+J *	0008	30 IR=1			
0010 D() 90 J=1,N 0011 R(1R)=0 0012 D0 80 I=1,M 0013 IF(MS) 40.60,40 0014 40 CALL LUC(J,I,IA,N,M,MSA) 0015 CALL LUC(I,K,IB,M,L,MSB) 0016 IF(1A) 50,80,50 0017 50 IF(IB) 70,80,70 0018 G0 IA=N*(I-1)+J	0009	D() 90 K=1.	, L	4	
0011 R(1R)=0 0012 DU 30 [=1, M 0013 IF(MS) 40.60,40 0014 40 CALL LUC(J,I,IA,N,M,MSA) 0015 CALL LUC(I,K,IB,M,L,MSB) 0016 IF(1A) 50,80,50 0018 60 IA=N*(I-1)+J	0010	DO 90 J=1	• N		
0012 D0 80 I=1,M 0013 IF(MS) 40.60,40 0014 40 CALL LUC(J,I,IA,N,M,MSA) 0015 CALL LUC(I,K,IB,M,L,MSB) 0016 IF(IA) 50,80,50 0017 50 IF(IB) 70,80,70 0018 60 IA=N*(I-1)+J	0011	R(1R)=0			
0013 IF (MS) 40,60,40 0014 40 CALL LUC(J,I,IA,N,M,MSA) 0015 CALL LUC(I,K,IB,M,L,MSB) 0016 IF (IA) 50,80,50 0017 50 IF (IB) 70,80,70 0018 60 IA=N*(I-1)+J	0012	1 = 1 0 = 0	i M		
0014 40 CALL LUC(J,I,IA,N,M,MSA) 0015 CALL LUC(I,K,IB,M,L,MSB) 0016 IF(IA) 50,80,50 0017 50 IF(IB) 70,80,70 0018 60 IA=N*(I-1)+J	0013	IF(MS) 40	•60 •40		
0015 CALL LUC(I,K,IB,M,L,MSB) 0016 IF(IA) 50,80,50 0017 50 IF(IB) 70,80,70 0018 60 IA=N*(I-1)+J	0014	40 CALL LUC(J.I.IA,N,M,MSA)		
0016 IF(IA) 50,80,50 0017 50 IF(IB) 70,80,70 0018 60 IA=N*(I-1)+J	0015	CALL LUCI	I,K,IB, M, L, MSB)		
0017 50 1F(IB) 70,80,70 0018 60 1A=N*(I-1)+J	0016	IF(1A) 50	,80,50		
0018 60 IA=N*(I-1)+J	0017	50 IF(IB) 70	80,70		
	0018	60 IA=N*(I-1) + J		

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0019				1B=M*(K-1)+1					
0020			70	R(IK)=R(I	R)+A(IA)+B(IB)					
0021			80	CONTINUE						
0022			90	IR=IR+1						•
0023				RETURN					•	
0024				END	· '			n en La sector		

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		С.,	******	**********	********	*******	*********	******
0001			DOUBLE, PH	ECISION LITL	2,13,14,15	,K1,K2,K3,	K4,K5,DCOS	DSIN, DATAN,
			*AA.88.6C.	DD.EE.FF.Al.	BL.L.DL.F	1.F1.G1.H1	. 11 . R1 . CX . S	X. CTX. DSURT.
			*12.13.14.	ALP.CA.MI.ME	.0M2.0M3.0	M4.AJ.BJ.C	J-DJ-EJ-EJ.	AL PH2 . AL PH3 .
			*AL PH4 . DCC	T.PI.XP.YP.X	X.YY.NXP.N	YP		
			* DNTY VOI	1. 1012. 1013.	VOL 4 . X AA . X	BA. YAA. YBA	.M1 . M2 . M3 . J	44
			*. 62. 63. 64	G5.H2.H3.H4	. 45. 12. 13.	14.15.05.0	2.03.04.121	17
			* CI CE	1001121101114	1131121131			
			* 101 10C	04 05 07 07				
			WYDAG VOAG		HO APALIT	PAL , XPAZ , T	PAZ . XPA 3. TI	A3, XPA4, TPA4,
0007			*XPAD, TPAD	0 M21 M22 M23	+M24+66			
0002			DIMENSIUM	ALIGUUI, BLI	8001.K(100	01.0(1000)		
0003								
0004			L2=10.0					
0005			L3=30.0					
0006			L4=25.0					
0007			L5=30.0					
8000			K1≃L5/L1					
0009			K2=L5/L4	1 C C C C C C C C C C C C C C C C C C C				
0010			K3=(L1*L1	-13*13+14*14	+15+151/12	.0*L1*L4)		
0011			C1=0.0030	679615				
0012			K4=L5/L3					
0013			K5=114+14	-L5*L5-L1*L1	-L3+L3)/(2	.0*L1*L3)		
0014			121=12-2-	0				
0015			1 22=1 2-4.	0				
0016			123-12-6	0				
0017			124-12-0	0				
0017			L24-L2-0.	10 16 71 4 2				
0018		r.	P1=3.1420	57145				
		C	S THE	SPEED OF RO	TATION OF	THE INPUT	LINK = 300 F	.P.M.
0010		L	(-200 O					
0019			34300.00					
0020			UM2=12.04	P1#51/60.0				
0021		_	PZ=-10.0					
0022			> P2=P2+10.	.0				
0023			12=(P2=2	0#P1)/(360.0	1			
0024			AA=DCOS(T	2)+K3-K1-(K2	*DCOS(12))			
0025			BB=-2.0*C	SIN(T2)				
0026			CL=K1+K3-	(1.0+K2)*DC0	S(T2)			
0027			DD= (K 4*DC	.OS(T2))+DCOS	(T2)+K5-K1			
0028			EE=-2.0*0	SIN(T2)				
0029			FF=(K4*DC	OS(T2))-DCOS	(T2)+K5+K1			
0030			T3=2.0+(C	ATAN((-EE-DS	URT(EE *EE-	4.0*DD*FF))/(2.0+DD)))
0031			T4=2.0*(D	ATAN((-BB-DS	QRT (BB*BB-	4.0*AA*C())/(2.0*AA)))
0032			CX=DCUS(I	4-13)				
0033			SX=DSIN(T	4-13)				
0034			CTX=CX/S	(
0035			ALP=PT/3.	0				
0036			Y D= (11*DC	OC 17211+112#		211		
0037				US 11211 +112+	DCDJIALFVI	211		
0031			- TETELEUS - TEM X~11 1±0)	23278886841 23377886841	577 INCT2-TAN		
0030				M3+05IN(14-1	2117162403	111112-1411		
00.33				112 TUS LINE 12-1	3/1/ (L4+US	10114-1311		
0040		1	AJ=L4¥USI	N(14)				
0041			BJ=L3*DS1	N(13)				
0042			CJ=(L1*ON	12*0M2*DCOS(T	2))+(L3*UM	3*0M3*DCOS	(T3))-(L4*0)M4*0M4*DCOS(14
			*))					· · · ·
0043			DJ≃L4*DCC	IS (14)				
0044			EJ=L3*UCC	IS(T3)				
0045			FJ=(L4*0M	14*0M4*)SIN(T	4))-(L1*OM	2*UM2*DSIN	(T2))-(L3*()M3*OM3*DSIN(T3

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	*))			
0046	ALPH2=0.0			
0047	ALP+3=(CJ*	DJ-AJ*FJ)/(AJ*EJ-	BJ*DJ)	
0048	ALPH4={CJ+	EJ-BJ*FJ)/(AJ*EJ-	BJ*DJ)	
0049	XPA=-(L1×C *ALP+T3))-(JM2 *0M2 *0C0S (T2))-	(L1*ALPH2*DSIN(T2))-(L2 +T3))	*UM3*UM3*DCOS(
0050	YPA=(L1*AL	PH2*DCOS(T2))-(L1	*0M2*0M2*DSIN(T2))+(L2*	ALPH3*DCOS(ALP+
0051	ΥΔΔ±(11×0	SIN(T2) *A) PH2)-(1	J/# 1まDCのS/T21±CM2±CM21	
0052		OS(T2) *ALPH21=(11	±151N(T2) ±0M2±0M2)	
0053	$YBA = -(1) \pm A$		1±002±002±002±0021	*****
0055	*))+(L3*ALP	H3*DSIN(T3))	1+0H2+0H2+0C03(12/)-(15	+UM3+UM3+UCU3(13
0054	¥8A≃-(L1*(*))+(L3*ALP	JM2 *UM2 *DS [N (T 2)) + PH3 *DCOS (T 3))	(L1*ALPH2*DC0S(T2))-(L3	*0M3*0M3*D SIN(T3
	C			
	C #ALL LINKS	AKE OF UNIFORM CI	RCULAR CROSS-SECTION OF	DIA.=0.5 IN. *
	C *"CA"-CROSS	S-SECTIONAL AREA O	F ALL LINKS.	*
0055	CA=0.19634	95408		
	C *CE THE	MODULUS OF ELAST	ICITY.	*
0056	CE=1000000	0.0		
	C *"MI"-CRUSS	-SECTIONAL MOMENT	OF INERTIA.	*
0057	MI=0.00306	79615		
0058	A1=DCOSIT2	•		
0059	BI=-DSIN(T)	2)		
0060	CI=DCOS(T4	+)		
0061	D1=DSIN(T2	1		
0062	E1=OCUS(T2	2)		
0063	F1=DSINIT4	+1 · · · · · · · · · · · · · · · · · · ·		
0064	G1=-(L2*DC	OS (ALP+T3) *DCOS (T)	2))+(L2*DSIN(ALP+T3)*DC	DS(T2))
0065	G2=-(L21*D	CUS(ALP+T3) +DCOS([2))+(L21*DSIN(ALP+T3)*	DCOS(T2))
0066	G3=-1L22*D	COS(ALP+T3) *DCOS([2])+(L22*DSIN(ALP+T3)*	DCOS(T2))
0067	G4=-(L23*U	COSIALP+T3)*DCOSI	[2]]+(L23*DSIN(ALP+T3)*	DCDS(T2))
0068	G 5=−(L24×D	CUSLALP+T31*DCOS(T2))+(L24*DSIN(ALP+T3)*	DCOS (12))
0069	H1=+(L2*DC	OS (ALP+T3) *DCOS(T)	2))-(L2*DSIN(ALP+T3)*DS	IN(T2))
0070	H2=-(L21+D	CUSIALP+T3) +DCOS(T2))-(L21*DS IN(ALP+T3)*	DSIN(T2))
0071	H3=-(L22*0	CUS(ALP+T3) +DCOS(T2))-(L22*DSLN(ALP+T3)*	DSIN(12))
0012	H4=-(L23*D	COSIALP+T3) +DCUSI	[2])-(123*DSIN(ALP+T3)*	DSIN(12))
0073	H5=-(L24*D	CUS(ALP+T3) *DCOS([2])-(124*DS]N(ALP+I3)*	DSIN(T2))
0074	11=DSIN(T4)*((L3*)COS(T3))-((L2#0C3S(ALP+T3)))+DCOS	(T4) * ((L2*DSIN(A
0075	12=0 SIN(T4	.) *((3*DCDS(T3))	(121*)COS(ALP+T3)))+DCO	
	*(AL P+T3))~	$(1.3 \times 0.5 \text{ IN}(T.3.1))$		J1147+11221+031N
0076	13=0 SIN(T4	$) \neq ((13 \neq 0.05(T3)) =$	(1 22 * UCOS (AL P+T3)))+OCO	S(TA) #//1 22#DSIN
	*(ALP+T3))-	(L3*DSIN(T3))		J (4) + ((2 2 + 0 3 I N
0077	14=DSIN(T4)*((L3*0CUS(T3))-	(L 23*DCOS (AL P+T 3)))+9CO	S(T4)*(1123*DSIN
	*(ALP+T3))-	(L3*DSIN(T3)))		
0078	15=DSIN(T4)*((L3*UCOS(T3))-	(124*DCOS(ALP+T3)))+DCO	S(T4)*(1124*DSIN
	*(Δi P+T3))-	(1.3*DSIN(T3)))		
0079	R1=(A1*(F1	*[]-F]*H])]-(R)*()))*[]-F]*G]))+(()*())*()	I-E1*G11)
0080	$R_2 = (\Delta 1 \neq \ell F_1)$	*12-F1*H211=(81*())]* 2~~~~[*62])+(()]*(0]*()	2 - E 1 # G2))
0081	$R_3 = (\Delta 1 \neq I \in I)$	*[3-F]*H3)]=(k1*())]*[3-E1*C3))+(()*(D1*0	3-61±0211
0082	R4=(A1*(E1	*[4-F]*H4))-(B]*([)1*[4-F1*G4])+(C1*(D1*H	+-E1*G4))

F OR TRAN	I۷	G 1	RELEASE	2.0		MAIN			DATE	=	770	74		20/1	4/13
0083				ĸ5 =(/	A1#(E1#15-F1	*H5))-(E	01*(D1*	15-F	1+65))+	(C1	* (D1 *	H5-E1	*G5))	
0084				XPA1=	=-(L1*0M2*0M	2*DCDS(1	2))-(L	1+AL	PH2+	DSI	N (T)	2))-(L2*0M	3*0M3	*DCOS(A
0000				*LP+T	3))-(L2*ALPH	3* DS IN(/	ALP+T3))						Ma+04	1 40 6 0 6 1
0085				XPAZ	==(L1=UM2=UM T3}_=/ 7]#A		1211-LL 11AL 0+T	1*AL 311	PHZ+	021	NUL	211-1		mu+cm	5+00031
0086				XPAR	==(11*OM2*OM	2*06051	(ACF -)	1 \$ 41	PH2 #	กรา	NIT	211-1	122*0	N 340M	3*00051
0000				*ALP+1	T3))-(L22*AL	PH3+DSIN	ILALP+T	3))		05.					5 50551
0087				XPA4	=- (L1 * OM2 * UM	2+DCUS (1	(2))-(L	1*AL	PH2*	DS I	NET.	2))-1	L 2 3 * 0	M 3*0M	3*DC05(
				#ALP+	T3))-(L23*AL	PH3+DSI	NALP+T	3))							
0088				XPA5	=-{L}*0M2*0M	2*DCOS([2])-(L	1*AL	PH2*	DSI	NIT.	2))-	[124*0	M3*0M	3*DCOS(
0000				*ALP+	13))~(L24*AL	PH3*DS1	N (AL P+1	3)) 14240	M3+D	C T N.	113	· · · / ·	2 + 41 0	12+DC	0014101
0089				****	= (L1+ALPH2+U = (2±0M3±0M3	TOSTICI.	D+T 311	mz+u	mz • D	21 14	(12	11+0	LZ + ALP	n3+00	USIALPT
0090				YPA2:	= (1 * A PH2 * D	COS(T2)	(L1*0	M2 *0	M2 * D	S I N	(12))+(i	21 * Ai	Р H3 * D	
				*+T3))-(L21+UM3+0	M3*DSIN	ALP+T3))							
0091				YPA3	= (L1*ALPH2*D	COS(T2))-(L1#O	M2*0	M2*D	SIN	(T2))+()	22*AL	PH3*D	COSIALP
				*+T3))-{L22*0M3*0	M3 * D S I N	LALP+T3))							1 A.
0092				YPA4	= (L1*ALPH2*D	COS(T2))-(L1*0	M2*0	M2 * D	SIN	112))+(23*AL	PH3*D	COSIALP
0003				#+13): VDA6-)-(L23*UM3*U -(L1+AL042*D	M37051N	(ALP +1 3	1)) 1)/2 = k (1)	M2+D	C T NI	112	1 1 4 1 1	26 # 11	0 43 *0	COCLARD
0095				*+[3]	~ (LIFALPHZFU)-(24*0M3*0	N3#DSIN	ΔΙΡ+Τ3	1112 + O	m2 + U	21.14	(12	11+()	24 TAL	r no + 0	CUSTALF
			C					••							
			Ĉ -	DENS	ITY OF ALUMU	NIUM IS	0.098	LB/C	U.IN	•					
			C		•										
0094				DNT Y	=0.098										
0095				VUL 2:	=(A #L 2										
0096					1=6A=621 2=6A=122		;								
0098				VUL2	3=CA*L23										
0099				VUL 24	4=CA*L24										
0100				M2=V0	()L2*DNTY										
0101				M21=	VUL21*DNTY										
0102				M22=1											
0103				M23=											
0104				GC=1	2.178*12.0										
0106				P1=()	XPA1*M21/GC										
0107				22=()	YPA1*M2)/GC										
01.08				P3=0.	• 0										
0109				P4=()	XPA2#M21)/GC										
0110				P5=(YPAZ≢MZIJ/GU										
0112				P7=()	.0 XPA3*M22)/GC										
0113				P8=()	YPA3*M22)/GC										
0114				P)=)	- 0										
0115				P10=	(XPA4*M23)/G	C .									
0116				P11=	(YPA4*M23)/G	<i>с</i>									
0118				P12≠0 P13≠0	(¥PA 5*M2 4) /G	r									
0119				P14=	(YPA5*M24)/G	C									
0120				P15=	0.0	-									
			С												
			C C	THE	FORCE TRANSF	ORMATION	MATRI	ΧFJ	RLA	SE	N0.	3***:	*****	*****	* * * * * * *
0121				U(1) -	=DCOS(T3+ALP	1									
0122				U(2):	=-DSIN(T3+AL	P)									
0123				U(3)	=0.0 -//E1#111 /5	1+41111									
0124				0(4):	=1181=111-(F	T4HT111	CT.								

FORTRAN	[V G]	RELEASE	2.0				MAIN			DATE
0125			U(5)	=((F	1*G1)-(D	1+11))/R1		
0126			U(6)	= (()	1*H1	1-18	1*61))/R1		
0127			U(7)	=CTX	*DSI	N(T3	+ALP)*(L2/1	L31	
0128			U(8)	=-(D	SINC	T3+A	LP))	*L2		
0129			DO 5	0 1=	9,40					
0130		50	0(1)	=0.0						
0131			0(41)=DS	IN(T	3+AL	(P)			
0132			U(42)=DC	05 (T	3+AL	P)			
0133			U(43)=0.	0					
0134			U(44) = (C	1*H1	-B1*	11)/6	1 1		
0135			U(45) = (A	1+11	-C1*	G1)//	R1		
0136			U(46) = (B)	1*G1	-41*	H1)/F	31		
0137			U(47) = - (DCOS	(13+	ALP)) *C T X # ((L2/L3)	
0138			U(48) =DC	OS (T	3+AL	P)*L2	2		
0139			00 5	1 1=	49,9	0				
0140		51	U(I)	=0.0						
0141			0(91)=1.	0					
0142			0(92)=(8	L*F.1	-61*	E117	₹1		
0143			0(93)=((1*01	-A1*	F1)/(RI		
0144			0194	1=1A	1761	~81#	01171	KT		
0145			0195	1=~~	1776	و				
0146			0140	1=1.	0.7.1	2.0				
0147		6.2	00 5	21 = -00	91.1	28				
0140		22	0111	=0.0 o.v.=u						
0149			11113	01=1	(2)					
0151			11/13	11=11	(2)					
0152			11113	2)=1	F1#1	2-F1	*H214	182		
0153			11(13	2)=(E1*G	2-01	*12)	182		
0154			11(13	(4) = 1	01#H	2-F1	*G21	/R 2		
0155			003	5) = C	TX*D	SINC	T3+A	P)*1.21	1/13	
0156			U(13	6)=-	DSIN	(13+	ALP)	FL21		
0157			DU 5	3 [=	137.	168				
0158		. 53	U(1)	=0.0						
0159			U(16	91=U	(41)					
0160			U(17	0)=U	(42)					
0161			U(17	1)=0	(43)					
0162			U(17	2)=(С1*н	2-01	*12)	/R 2		
0163			U(17	3)=(A1 # I	2-C1	*G2)/	/R2		
0164			0(17	4)=(61*G	2-A1	*H2)/	/ R2		
0165			U(17	5)=-	(CTX)	*DCU	S(T34	⊦ALP)*i	211/L3	
0166			0(17	6) = 0	COSI	T3+A	LP)*l	21		
0167			00 5	4 I =	177,	210				
0168		54	0(1)	= 0 • 0						
0169			0121	1)=1	•0					
0170			0(21	2) = (81*8	1-01	*E1)/	R2		
0171			.0(21	31=(1-A1	.#h 117	/KZ		
0172			0(21	4)=l	ALYE	1-01	<i>∓0137</i>	RZ		
0173			0(21	51=-		13				
0174			0121	01=1	•U . ว17	264				
0175			005	- 0 0	211,	220				
0177		57	0117	71-11	(1)					
0178			11/25	11-0	(2)					
0179			11(25	9)=1	(3)					
0180			11126	(1) = 1	F1#1	3-F1	*H3.)	/83		
0181			U(26	1) = 0	E1*G	3-01	* [3]	(R3		
0182			11(24	21=1	n1*∺	3-F1	*6 31	/R 3		
0100			0120		0 L 11	1				

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FORTRAN	IV G1 RELEAS	SE 2.0	MAIN		DATE = 77074	20/14/13
0183		U(263)=C	TX+D SIN(T3+ALP)	*L22/L3	1	
0184		U(264)=-1	DSIN(T3+ALP)+L2	2		
0185		DO 56 I=2	265,296			
0186		56 U(I)=0.0				•
0187		U(297)=U	(41)			
0188		U(298)=U	(42)			la ser de la ser de la ser a
0189		U(299)=U	(43)			
0190		U(300)=((C1+H3-B1+I3)/R3			
0191		U(301)=(/	A1*I3-C1*G3)/R3			
0192		U(302)=(1	81#G3-A1#H3)/R3	, ·		
0193		U(303)≠-	(CTX*DCOS(ALP+T	3)#L22)/L3		
0194		U(304)=D(OS(T3+ALP)+L22			
0195		DO 57 I=	305,338			
0196		57 U(I)=0.0				
0197		U(339)=1.	0			
0198		U(340)=(1	B1#F1-C1#E1)/R3			
0199		U(341)=((C1+D1-A1+F1)/R3			
0200		U(342)=(/	1*E1-B1*D1)/R3			
0201	,	U(343)=-(CTX/L3			
0202		U(344)=1.	.0			
0203		DO 58 1=1	345, 384	1. 1.		
0204	, c	58 U([)=0.0				
0205		U(385)=U	(1)			
0206		U(386)=U	(2)			
02 07		U(387)=U	(3)			
0208		U(388)=(6	E1*I4-F1*H4)/R4	, ¹ - 1		
0209		U(389)=(1	F1*G4-D1*I4)/R4	н ^а .		
0210		U(390)=(1	01*H4-E1*G4)/R4	•		
0211		U(391)=C	TX#D SIN(T3+ALP)	+L23/L3		
0212		U(392)=-1	DSIN(T3+ALP)#L2	3		
0213		00 59 1=3	393,424			
0214	4	59 U(I)=0.0	•			
0215		U(425)=U	(41)			
0216		U(426)=U	(42)			
0217		U(427)=U	(43)			
0218		U(428)=(i	C1*H4-B1*[4)/R4	 A second sec second second sec		
0219		U(429)=(1	41*[4-C1*G4]/R4	ł		
0220	1	U(430)=(!	81*G4-A1*H4)/K4	•		
0221		U(431)=-	(CTX*DCDS(T3+AL	.P)*L23)/L3		
0222		U(432)=D(COS(T3+ALP)*L23	}		
0223		DO 60 I=4	433,466			
0224	(50 U(I)=0.0				
0225		U(467)=1.	.0			
0226		U(468)=(1	31*F1-C1*E1)/R4	• ¹ • •		
0227		U(469)=((C1*D1-A1*F1)/R4	•		
0228		U(470)=(/	A1*D1-B1*D1)/R4	ł		
0229		U(471)=-0	CTX/L3			
0230		U(472)=1.	• 0			
0231		DO 61 I=4	473, 512			
0232	t	1 U(I) = 0.0				
02 3 3		U(513)=U	(1)			
0234		U(514)=U	(2)			
0235		U(515)=U	(3)			
0236		U(516)=(1	E1#15-F1#H5)/R5			
0237		U(517)=(F1*G5-D1*15)/R5			
0238		U(518)=(1	01 *H5-E1 *G5)/R5			
0239		U(519)=C	TX*D SIN(T3+ALP)	*L24/L3		
0240		U (520)=-I	DSIN(T3+ALP)*L2	4		

FORTRAN	IV G1	RELEASE	2.0	MAIN	l, s	DATE =	77074	20/14/13
0241			DO 62 I=	= 521, 552				
0242		62	2 U(I)=0.0	0				
0243			U(553)=L	U(41)				
0244			U(554)=L	J(42)				
0245			U(555)=	1(43)				
0246			U(556)=	(C1#H5-B1#15)	/R5			
0247			U(557)=	(A1*15-C1*G5)	/R5		· •	
0248			11(558)=	(81+65-41+45)	/ R5			
0249			11(559)=-	-ICTX+DCOSIAL	P+T3) #1 241	/13		
0260			U(560)=	DCOS (T3+ALP)	124			
0251			00 63 1	±561.594		ι Gg		
0262		63		n				
0253			U(595)=1					
0254			11 5961=	B1*F1-C1*F11	185			
0254			11(597)=1	((1±01=41±51)	/05			
0295			11(598)=	(A1#61-81#D1)	/ 05			
0250			U(500)-	(AI+EL-DI+DI/				
0251			013991		'			
0258			0(6001=1	1.0				
0239			N=40					
0260		C	M=15					
		C C	FURCE T	RANSFER MATRI	X IS TRANS	SPOSED.		
0261			CALL GMT	TRA(U.R.N.N)	•			
0262			DO 100	1=1.600				
0263		100) A(I)=R()	0				
		c			1 . · · ·			
		C C	THE FUR	CE TRANSFER N	ATRIX IS I	NULTIPLIED	BY FLEXIBILI	TY MATRIX.
0264		ũ	B(1)=12	//CA#CE)				
0204				2.41				
0265				0				
0200			B(2)-0.0	2+12+121//2	0+CE+CI1			
0201			D1421-11	L Z TL Z TL Z I / L 30				
0208			81437=11	LZ+LZ // \Z+U+\	E+011			
0269				44,81				
0270		4	2 BIJJ=0.0					
0271			B(82)=(1		ETCEI			
0272			6(83)=L	2/((=+(1)				
0273			DU 3 J=8	84,123	•			
0274			3 B(J) = 0.0	0				
0275			8(124)=1	L1/(CA¥CE)	. •			
0276			DU 4 J=1	125,164				
0277		4	4 B(J) = 0.	0				
0278			B(165)=	(L1#L1#L1)/(3	.0*CE *CI			
0279			DO 6 J≖]	166,205				
0280		1 . I	6 B(J)=0.	0				
0281			B(206)=1	L4/(CA*CE)				
0282			D0 7 J=2	207,246				
0283			7 B(J)=0.0	0				
0284			B(247)=	L3/(CA*CE)				
0285			D0 8 J=	248,287				
0286		1	B B(J)=0.0	0				
0287			B(288)=	L3/(3.0*CE*CI	()			
0288			DO 9 J=	289.328				
0289			$B(J) = 0_{-}(0)$	0				
0290			8(329)=	L21/(CA*CE)				
0201		•		= 330.369				
0291		1.6) B(1)=0 4	0				
0676				•				

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0293				B(370)=	(L21*L21	*L 21)/(3.	U*CE*CI)		
0294				B(371)=	(L21*L21)	1/ (2.0+CE	*C.L)		;
0295				00 11 5	= 372,409				
0296			. 11	B(J)≠0.	0				
0297				B(410)=	(121*121))/(2.0*CE	+CI)		
0298				B(411)=	L21/(CE*((1)			
0299				DO 12 J	=412,451				
0300			12	B(J)=0.	.0			· · ·	
0301				B(452)=	L1/(CA*CE	E) -			
0302				DO 13 J	=453,492				
0303			13	B(J)=0.	0				
0304				B(493)=	(L1+L1+L)	L)/(3.0*C	E*C1)		
0305				DO 15 .	=494,533				
0306			15	B(J)=0.	0				
0307				B(534)=	L4/(CA+CE	E)			
0308				00 16 .	= 535 , 574				
0309			16	B(J)=0.	0				
0310				B(575)=	L3/(CA+CE	Ξ)			
0311				00 17 .	= 576, 615				
0312			17	8(J)=0.	0				
0313				8(616)=	L3/(3.0*	CE*CI)			
0314				DD 18 .	=617.656				
0315			1.6	(B(J) = 0.	0			•	
0316				B(657)=	1 22/1 64 *(° F)			
0317				00 19	1=658-697				
0318			19	61.1)≠0.	0				
0319		4	• •	8/69813	11 2241 22	1 221713			
0320				816991=	1122+122	//2.0*CF	*CI)		
0321				00 20	= 700. 737				
0322			20	B(1)=0.	0				
0323			. 20	8(738)-	1122#1221	112 046	*****		
0324				A(739)=	1 22/// 6*	1712-0-00	+017		
0325				0021	-740.770				
0325			21	91121 3	0				
(1227			21	a(790)-		- 1			
0328				00.22	=781-820	- - -			
0320					0				
0330				8/8211=	(1.1*1.1*1	1/13.0#	E#C T)		
0331				00217-	1-433 041	1713.040			
0332					0.				
0332			2-	0/0/71-0-		-			
0336					L4/10A+01	: : :			
0334			27		003190Z				
0335			27		1 3// 6 1 # 6	= 1	5418		
0930				00 25	-004 043	- - -			
0337			25		0		÷		
0550			. 23	D(J)=0.					
0339				0(944)=	E3/E3.0%(.E+011			
0340			2		1=942+904				
0341			26	0 (005)	U				
0342				 	L23716A*(
0343					1=986,1025	>			
0344			27	B(J)=0.	0				
0345				8(1026)	= (L23 = L2)	5+1231/13	.U#62761)		
0346				8(1027)	≈1L23*L23	517 (2.0*0	モギしこ)		
0347				DU 28 J	I= 1028 , 10 0	55			
0348			28	B(J)=0.	.0				
0349				8(1066)	=(L23+L23	6)/(2.0*C	.E∓C11		
0350				B(1067)	=L23/(CE	PC(1)			

ORTRAN	ΙV	Gl	RELE	ASE	2.0	MAI	IN	DATE =	77074	20/14/13
0351					Du 29 J	= 1068, 1107				· · · ·
0352				29	B(J)=0.0) [,]				
0353					B(1108):	=L1/(CA*CE)				
0354					DO 30 J:	= 1109, 1148				
0355			аны на 1997 година 1997 година	-30	8(J)=0.0)	1	an a		
0356					B(1149):	=(L1+L1+L1)/	(13.0*CE*CI)			
0357					DU 31 J=	=1150,1189				
0358				31	B(J)=0.0)				
0359					B(1190)	=L4/(CA*CE)	•	•		
0360					DO 32 J:	= 1191 , 1230				
0361				32	B(J)=0.0)				
0362					8(1231):	=L3/(CA+CE)				
0363					DU 33 J:	= 1232, 1271				
0364				33	B(J)=0-0)				
0365					B(1272)	=L3/(3.0*CE*	*C1)			
0366				1	DO 34 J	= 1273, 1312				
0367				34	B(J)=0.()				
0368					8(1713)	=L24/(CA *C E)	the state of the s			
0369					DO 35 J	= 1314, 1353				
0370				35	B(J)=0.0)		11. A 19 19 19 19 19 19 19 19 19 19 19 19 19		
0371					B(1354)	=(L24*L24*L2	24)/(3.0*CE*	CI		
0372					8(1355)	=(L24*L 24)/(2.0*CE*CI)			
0373					00 36 J:	=1356,1393				
0374				36	B(J) = 0.0)				
0375					B[1394]	=(L24*L24)/(2.0#CE#C1)			
0376					8(1395)	=L24/ (CE*CI)				
0377					00 37 J=	=1396,1435				
0378				37	B(J)=0)	-			
0379					8(1436):	=L1/(CA*CE)				
0380				-	DO 38 1:	=1437,1476	2 · · ·			
0381				38	B(J)=0.0)				
0382					B(1477):	=(L1+L1+L1)/	(3.0*CE*CI)			
0383				-	DO 39 J	=1478,1517				
0384				39	B(J)=0.0)				
0385					8(1518)	=L4/(CA+CE)				
0386					00 40 J	= 1519, 1558				
0387				40	B(J)=0.)				
0388					8(1559)	*L3/(CA#CE)				
0389					D() 41 J	1560,1599				
0390				41	B(J)=0.(
0391					B(1600)	=L3/(3.0#CE*	(CD)			
0392					N=15					
0393					M=40					
0394					MSA=0					
0395					MSB=0					
0396					L=40					
0397					CALL MP	RD(A, B,R,N,N	4, MS A, MS B, L J			
0398				• • •	00 200 1	1=1,600				
0399				200	A(1)=R(1)	L			
			ć		THE DEC		H TTOLTED DY	THE CODEE	TRANCES	MATOIN
			L C	1.1	THE RESI	JETANT IS MU	SCIENCED BY	INE FURCE	INANSPER	PATRIA.
0100			Ĺ							
0400						USLISTALPI				
0401					U(2)=+D	SINCISTALP)				
0402					0(3)=0.0	J. - 1 - 1 - 1 - 1 - 1				
0403					0(4)≠(()	51711/~(F1#F	11 1 1 / KL			
0404					U(5)=(()	-1=G1)~(D1=I	1117/R1			
0405					U(6)≠((I	J1#H1]~(E 1 #0	51)]/R1			

FORTRAN	11	G 1	RELEASE	2.0	MAIN	DATE	77074
04 06				U(7)	=CTX*DSIN(T3+ALP)*(L2/L3)		
0407				0(8)	=-(DSIN(T3+ALP))*L2		
0408				00 7	0 1=9.40		
0409			70	U(1)	=0.0		
0410				U(41)=DSIN(T3+ALP)		
0411				U(42)=DCDS(T3+ALP)		
0412				U(43)=0.0		
0413				U(44)=(C1*H1-B1*I1)/R1		
0414				U(45)=(A1*I1-C1*G1)/R1		
0415				U(46	=(B1+G1-A1+H1)/R1		
0416				U(47) =- (DCDS(T3+ALP)) *CTX*(L2/L3)		
0417				U(48)=DCOS(T3+ALP)+L2		
0418				DO 7	1 1=49,90		
0419			71	U(I)	=0.0		
0420				U(91)=1.0		
0421				U(92)=(81*F1-C1*E1)/R1		
0422				0193	$)=(C_1*D_1-A_1*F_1)/R_1$		
0423				U194) = (A1 + E1 - B1 + D1)/R1		
0424				U(95)=-CTX/L3		
0425				U196)=1.0		
0426				DO 7	2 [=97.128	.*	
0427			12	U(I)	=0.0		
0428			• -	0(12	9)=((1)		
0429				11(13	() ≠U(2)		
0430				11/13	1)=11(3)		
0431				1113	2)=(F]+[2-F]+H2)/R2		
0432				11113	$21 \pm (51 \pm 0.2 - 0.1 \pm 1.2)/R2$		
0433				11/13	4)=(D1±42=E1±C2)/22		
0435				11(13	51=(11*n2'01*02//K2		
0436				11/12			
0436				00.7	3 I=137.168		
0430			73		-0.0		
0434				11/16	(0.0)		
0430				11/17	(1) - (1/42)		
0440				11(17			
0440				0117	21-0(43)		
0441					2)=(01+02=01+12)/82		
0442					31-141+12-01+02// K2. 41-(91+02-41+03)/ P3		
0443				0117	4) ~(DI + 62 - AL + 62 / 82,		
0444				0117			
0445					0/=DCUS(15+ALP)+L21		
0440				.00 7	4 1=1//+210		
0447			14	0(1)			
0448				0(21	1/=1+U		
0449				0(21	21=101+01 41+01/K2		
0450				0(21	3]={\L+U1-A1+F1}/K2		
0451				0121	4)=(AI+EI-BI+UI)/K2		
0452				ULZI	5)=~CIX/L3		
0453				0(21	0)=1.0		
0454			·	00 7	5 1=217,256		
0455			75	U(I)	= U• U		
0456				U(25	<i>(</i>]=U(1)		
0457				U(25	8]=U(2)		
0458				0125	9)≖U(3)		
0459				U(26	0)=(E1*13-F1*H3)/R3		
0460				0126	1) = (F1 + G3 - D1 + I3)/R3		
0461				U(26	2]=(U]+H3-E1+G3)/R3		
0462				U126	3)=CTX*DSIN(T3+ALP)*L22/L3		
0463				U(26	4) =- DSIN(T3+ALP) *L22		

FORTRAN	١v	G1	RELEASE	2.0	MAIN	QATE	=	770
0464				DO	76 1=265,296			
0465			76	UCI)=0.0			
0466				U(2	97)=U(41)			
0467				U(2	98)=U(42)			
0468				0(2	99)=U(43)			
0469				U(3	00)=(C1+H3-B1+[3)/R3			
0470				0(3	01)=(A1+13-C1+G3)/R3			
0471				U(3	02)=(B1*G3-A1*H3)/R3			
0472				013	03)=-(CTX*DCOS(ALP+T3)+L22)/L3			
0473				0(3	04) ⇒DCOS(T3+ALP)*L22			
0474				DO	77 1=305,338	•		
0475			17	001]=0.0			
0476				U(3.	39)=1.0			
0477				Ų(3	40)=(B1*F1-C1*E1)/R3			
0478				0(3	41)=(C1*D1-A1*F1)/R3			
0479				0(3	42)=(A1*E1-B1*D1)/R3			
0480				0(3	43)=-CTX/L3			
0481				U(3)	44)=1.0			
0482				DO	78 I= 345, 384			
0483			78	0(1)=0.0			
0484				U(3	85)=U(1)			
0485				U (3	86)≖U(2)			
0486				013	87)=U(3)			
0487				U(3	88)=(E1*I4-F1*H4)/R4			
0488				U(3	89)=(F1*G4-D1*I4)/R4			
0489				U(3	90)=(D1*H4-E1*G4)/R4			
0490				U(3	91)=CTX+DSIN(T3+ALP)+L23/L3			
0491				U(3	92)=-DSIN(T3+ALP)*L23			
0492				DO	79 1=393,424			
0493			79	ULI)=0.0	17.1		
0494				U(4	25)=U(41)			
0495				U(4	26) =U(42)			
0496				U(4	27)=U(43)			
0497				U(4	28)=(C1*H4-B1*[4)/R4	2		
0498				U(4	29)=(A1#I4-C1*G4)/R4			
0499				014	30)=(B1*G4-A1*H4)/R4			
0500				U14	31) = - (CTX * DCOS (T3 + ALP)) * L23/L3			
0501				U(4	32)=DCUS(T3+ALP)*L23			
0502				D0	80 I=433,466			
0503			80	ULI)=0.0			
0504				U(4	67)=1.0			
0505				0(4	68)=(B1*F1-C1*E1)/R4			
0506				0(4	69)=(C1*D1-A1*F1)/R4			
0507				U(4	70) = (A1 + D1 - B1 + D1) / R4			
0508				014	71) = -CIX/L3			
0509				014	72)=1.0			
0510				DO	81 I=473,512			
0511			81	ULL)=0.0			
0512				0(5	13)=U(1)			
0513				015	14)=U(2)			
0514				U15	15)=0(3)			
0515				0(5	16)=(E1*I5-F1*H5)/R5			
0516				015	17) = (F1 + G5 - D1 + I5)/R5			
0517				015	18)=(D1*H5-E1*G5)/R5			
0518				0(5	19)=CTX+DSIN(T3+ALP)+L24/13			
0519				015	20)=-DSIN(T3+ALP) *1 24			
0520				00	82 1=521.552			
0521			82	ULT)=0.0			

FORTRAN	IV	61	RELEASE	2.0	MAIN		DATE =	77074	20/14/13
0522				U(553)≠U(41)					
0523				U(554)=U(42)					
0524				U(555)=U(43)					
0525				U(556)=(C1*H5-B	1*151/R5				
0526				U(557)=(A1*15-0	1*65)/R5				
0527				U(558)=(B1+G5-A	1*H5)/R5				
0528				U(559)=-(CTX*DC	OS(ALP+T3)	*L24)/L3			
0529				U(560)=DCOS(T3+	ALP) #124				
0530				DU 83 1=561.594	• · · · · · ·				
0531			83	U(I)=0.0					
0532				U(595)=1.0					
0533				U(596)=(B1*F1-C	1*E1)/R5				
0534				U(597)=(C1*D1-A	1#F1)/R5				
0535				U(598)=(A1*E1-E	1*D1)/R5				
0536				U(599)=-CTX/L3					
0537				U(600) = 1.0					
0538				N=15					
0539				M=40					
0540				MSA=0					
0541				MSB=0					
0542				L=15					
0543				CALL MPRD (A.U.R	.N.M.MSA.M	SB,L)			
0544				DU 300 1=1,225					
0545			300	A(I)=R(I)					
			C	THE RESULTANT I	S MULTIPLI	ED BY THE	INERT	IA MATREX	(• • • • • • • •
0546			U	B(1) = P1					
0547				B(2) = 72	•				
0548				B(3) = P3					
0549				B(4) = P4					
0550				B(5) = P5	4				:
0551				B(6)=P6					
0552				B(7)=P7					
0553				B(8)=P8					•
0554				B(9)=P9					
0555				B(10)=P10			,		
0556				B(11)=P11					
0557				B(12)=P12					
0558				B(13)=P13	i				
0559				B(14)=P14					
0560				B(15)=P15	2000 A				
0561				CALL MPRD(A, B, R	.N.M.MSA.M	SB,L)			
0562				N=15					
0563				M=15					
0564				MSA=0					
0565				MSB=0					
0566				L=1					
0567				CALL MPRDIA, B, P	.N.M.MSA.M	SB,L)			
0568				WRITE(6,500)P2	R(1),R(2),	R(3),R(4)	,R(5),	R(6),R(7)	,R(8),R(9),R(10),
				*R(11) .R(12) .R(1	3) .R(14) .R	(15)			
0569			500	FORMAT('1'.F18	10,3(8X.F1	8.10)///	0',18X	,318X,F18	3.10)///'0',18X,3(
			200	*8X,F18.10)///'0	,18X,3(8X	F18.10)	// 101,	18X, 3(8X,	F18.10))
0570			· ·	IF(P2.GT.360.0)	GU TO 999				
0571				GO TO 5					
0572			999	STOP					
0573				END					

VITA

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Master of Science

Thesis: KINETO-ELASTODYNAMIC ANALYSIS OF A FOUR-BAR AND ITS COGNATE MECHANISM

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