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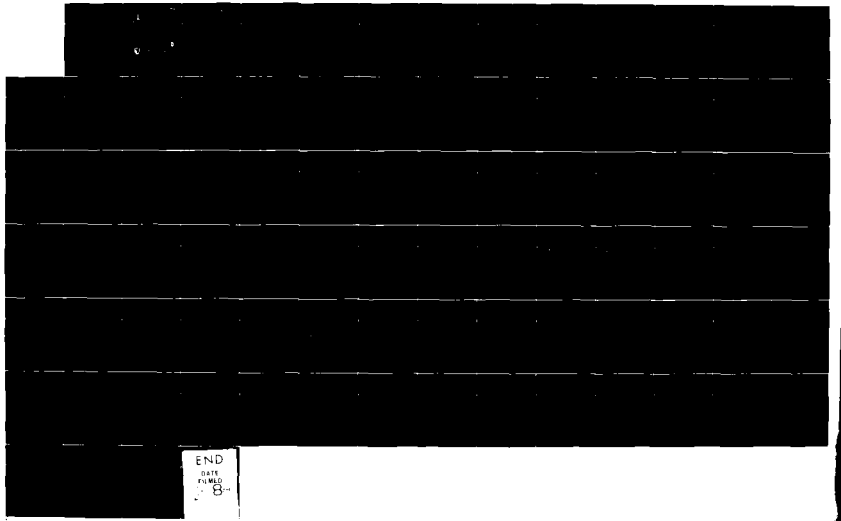

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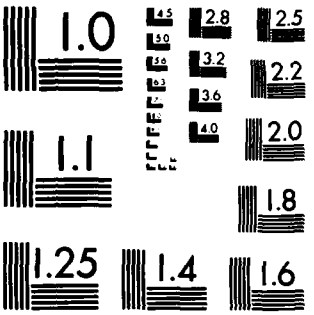

TECHNICAL REPORT RG-85-20

INTERACTIVE TIME RECURSIVE STATE ESTIMATOR PROGRAM

Sandra Brazelton
Guidance and Control Directorate
US Army Missile Laboratory

May 1985

U.S. ARMY MISSILE COMMAND
Redstone Arsenal, Alabama 35898-5000

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Predictor/estimator logic

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The SHORAD C^2 system consists of the equipment necessary to provide command and control capability for Army divisional and non-divisional Air Defense Artillery (ADA). This report describes a technique for smoothing noisy track data using a GHK discrete time-recursive state estimator program. This computer program was developed as part of an analysis of SHORAD track management functions. This system will show how accurately a target can be tracked given the appropriate input values.

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

I. INTRODUCTION

The Short Range Air Defense Command and Control (SHORAD C^2) system consists of the equipment necessary to provide C^2 capability for Army divisional and non-divisional Air Defense Artillery (ADA). It will provide C^2 for all echelons of a SHORAD battalion. The network will consist of displays, data processors, interface equipment, and sensors. The major objectives of the system are:

- Provide automated alert to all SHORAD battalion elements.
- Provide for automatic exchange of command information between SHORAD battalion elements.
- Provide weapon cueing to selected SHORAD battalion elements.
- Provide track information from the various sensor inputs to SHORAD C^2. This involves track management functions which include track file management and track smoothing operations.

Track files from external sensors such as PATRIOT, TSQ-73, HAWK, ADEWS, and AWACS feed data into high level modes of SHORAD C^2. Track management functions include the maintenance, correlation, triangulation and smoothing of track data. This report descibes a technique for smoothing noisy track data using a GHK discrete time-recursive state estimator program. The GHK estimator is useful in smoothing noisy track data obtained from noisy measurement sensors in applications such as the C^2 system for SHORAD. This computer program was developed as part of an analysis of SHORAD track management functions.

A detailed description of inputs and calculations will be included in the discussion to assist the user in choosing the original values. In addition, examples of inputs, resulting calculations, and plots will be provided in the results to give the user a thorough understanding of the output. Also, the necessary system assignment statements to aid the user in obtaining a hard copy of the results will be included in Appendixes A - C.

II. DISCUSSION

Initial values are input to determine the initial position, velocity, and acceleration of the target. The program then estimates the current position, velocity, and acceleration at each discrete time, based on initial conditions and a predefined predictor/estimator logic. Noise and various maneuvers may be added to the true position to determine how accurately the estimator handles noisy sensor data on maneuvering targets. Plots of true and estimated positions may be obtained to analyze the adequacy of filtering logic.

NOTE: Name of output entered is used as graph title.

A. Inputs

1. Main Program Inputs

VARIABLE	FORMAT	DESCRIPTION
SEED	I5	Used to generate random numers. Must be an odd integer $0 < SEED < 32768$. The SEED is used to generate a unique set of random numbers.

XBAR	F8.2	Estimate of position.
XDBAR	E12.5	Time derivative estimate.
XDDBAR	E12.5	Estimate of acceleration.
B	E16.9	BETA - BETA may be entered from the keyboard or computed. Please refer to calculation section for computation.
G,H,K	E12.5	NOTE - G, H, and K are a function of BETA. Please refer to calculation section for computations.
SIG	F6.2	Noise SIGMA.
MEAN	F6.2	Noise MEAN.
Z1	E12.5	Initial true position.
XD1	E12.5	Initial time derivative.
TIME	F6.2	Initial time.
DELT	F6.2	Time increment.
TM	F6.2	Time of maneuver start.
IMAX	I3	Number of computation steps.

All inputs except IMAX and SEED are floating point.

NOTE: An option is available so that if one chooses to rerun the program, he will not have to reenter the original values. When this option is chosen, the user can change only the specific value(s) of interest to him.

2. Inputs for Subroutine BETA

TC	F5.2	Time constant
DELT	F5.2	Time increment

B. Computations

1. Subroutine BETA-BETA is computed as follows:

E = 2.718281828
LAM = 1./TC
X = LAM x DELT

BETA (B) = E**X

so BETA = .967216134.

2. Subroutine GHK

G = 1. - B**3
H = 3./2. x ((1.- B**2) x (1. - Y)); (Y = noisy position measurement)
K = 1./2. x ((1. - Y) **3))

3. Main Program

a. Target Computation

Target acceleration is computed as follows:

ZDD = 78.5 (T-TM)
IF (ZDD.GE.49.1) then ZDD = 49.1

User inputs

T - Initial start time

TM - Time when maneuver starts

Target velocity is modeled by:

Z1 - Initial true position
ZD - Time derivative
T - Start time

IF (T .GE. TM) Z = Z + 0.5 x ZDD x (T-TM) **2

(0.5 x ZDD x (T-TM)**2) = Position change due to maneuver

b. Noise Modeling

Subroutine GAUSS - Generates random numbers

GAUSS (NO, SIG, RMEAN, WG)

NO = Seed
SIG - Standard deviation
RMEAN = Desired mean of the normal distribution
WG = Value of the computed normal random variable

Y = Z + WG (where Y = noisy position measurement)

C. Logic

1. Estimating Logic

```
XBAR = XHAT + G x (Y-XHAT)
XDBAR = XDHAT + (H/DELT) x (Y-XHAT)
XDDBAR = ZDDHAT + ((2 x K)/(DELT**2)) x (Y-XHAT)
```

2. Predicting Logic

```
R = (DELT**2)/2.

XHAT = XBAR + XDBAR x DELT + XDDBAR x R
XDHAT = XDBAR + XDDBAR x DELT
XDDHAT = XDDBAR
```

III. RESULTS

Each value entered is repeated to provide the user with an opportunity to change or correct value(s). Moreover, one has the choice of printing detailed results for each step (Table 1), or a tabular summation of results (Table 2.)

Examples of inputs and corresponding results are shown in the figures that follow. For odd numbered figures, the time constant is 3. and DELT is .1, so BETA = .967216134.

IV. SUMMARY AND CONCLUSION

This system shows how accurately a target can be tracked given the appropriate input values. Therefore, it is very important to use the initial values that will yield feasible results. Any change in the main program input values on pages 1 and 2 will change the results.

When BETA = .8 (even numbered figures), the program is able to track the displacement vectors fairly accurately. For example, in Figure 7, (BETA = .967) there was more lag in the result, but the curve was smoother. In Figure 8 (BETA = .8) it tracked more accurately, but there was more noise. The program was able to track the velocity vectors much better with a BETA of .967 as opposed to a BETA of .8. The results depend on how closely the initial filter states correspond to the true state values and on the filter damping design, which is determined by the choice of BETA.

TABLE 1. Detailed Step by Step Results

```
                        INPUT SECTION
*****************************************************************
  NAME OF OUTPUT IS DISP VECTOR NO NOISE NO MANEUVER
  SEED FOR THIS RUN IS     1

       XDAR= 10270.00 XDBAR= -0.15000E+03 XDDBAR=  0.00000E+00

        THE VALUE OF BETA IS  0.96700000BE+00

        G=  0.957C393E-01 H=  0.3213094E-02 K=  0.179C34CE-04

        NOISE FACTOR IS   0.00 MEAN IS   0.00

        Z1= 0.100000E+05 ZD1= -0.300000E+03 ZDD=  0.00000E+00

        IMAX=  60

        T=   0.00 DELT=   0.10 TM=   10.00
*****************************************************************
```

RESULTS FOR STEP 1

T	XBAR	XDBAR	XDDBAR
0.10000E+00	0.10270E+05	-0.15000E+03	0.00000E+00

XHAT	XDHAT	XDDHAT
0.10255E+05	-0.15000E+03	0.00000E+00

Z	ZD	ZDD
0.99700E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.30300E+03	0.15000E+03	0.00000E+00

Y= 0.99700E+04 (Y-XHAT) = -0.28500E+03

RESULTS FOR STEP 2

T	XBAR	XDBAR	XDDBAR
0.20000E+00	0.10225E+05	-0.16012E+03	-0.11320E+01

XHAT	XDHAT	XDDHAT
0.10209E+05	-0.16023E+03	-0.11320E+01

Z	ZD	ZDD
0.99400E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.28483E+03	0.13980E+03	-0.11320E+01

Y= 0.99400E+04 (Y-XHAT) = -0.26842E+03

RESULTS FOR STEP 3

T	XBAR	XDBAR	XDDBAR
0.30000E+00	0.10180E+05	-0.16964E+03	-0.22059E+01

XHAT	XDHAT	XDDHAT
0.10163E+05	-0.17000E+03	-0.22059E+01

Z	ZD	ZDD
0.99100E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.27020E+03	0.13013E+03	-0.22059E+01

Y= 0.99100E+04 (Y-XHAT) = -0.23320E+03

RESULTS FOR STEP 4

T	XBAR	XDBAR	XDDBAR
0.40000E+00	0.10136E+03	-0.17916E+03	-0.32236E+01

XHAT	XDHAT	XDDHAT
0.10113E+05	-0.17940E+03	-0.32236E+01

Z	ZD	ZDD
0.99300E+04	-0.70000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.25600E+03	0.12034E+03	-0.32236E+01

Y= 0.99300E+04 (Y-XHAT) = -0.23315E+03

RESULTS FOR STEP 5

T	XBAR	XDBAR	XDDBAR
0.50000E+00	0.10092E+03	-0.16309E+03	-0.41473E+01

XHAT	XDHAT	XDDHAT
0.10074E+05	-0.19051E+03	-0.41373E+01

Z	ZD	ZDD
0.99450E+04	-0.70000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.24247E+03	0.11191E+03	-0.41373E+01

Y= 0.99500E+04 (Y-XHAT) = -0.23264E+03

RESULTS FOR STEP 6

T	XBAR	XDBAR	XDDBAR
0.60000E+00	0.10049E+05	-0.19660E+03	-0.50998E+01

XHAT	XDHAT	XDDHAT
0.10030E+05	-0.19717E+03	-0.50988E+01

Z	ZD	ZDD
0.95200E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.22935E+03	0.10334E+03	-0.50988E+01

Y= 0.95200E+04 (Y-XHAT) = -0.20966E+03

RESULTS FOR STEP 7

T	XBAR	XDBAR	XDDBAR
0.70000E+00	0.10007E+05	-0.20467E+03	-0.59600E+01

XHAT	XDHAT	XDDHAT
0.99805E+04	-0.20547E+03	-0.59600E+01

Z	ZD	ZDD
0.97900E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.21071E+03	0.95127E+02	-0.59600E+01

Y= 0.97900E+04 (Y-XHAT) = -0.19019E+03

RESULTS FOR STEP 8

T	XBAR	XDBAR	XDDBAR
0.80000E+00	0.99845E+04	-0.21274E+03	-0.67729E+01

XHAT	XDHAT	XDDHAT
0.99432E+04	-0.21341E+03	-0.67729E+01

Z	ZD	ZDD
0.97600E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.20453E+03	0.87264E+02	-0.67729E+01

Y= 0.97600E+04 (Y-XHAT) = -0.16322E+03

RESULTS FOR STEP 9

T	XBAR	XDBAR	XDDBAR
0.90000E+00	0.99023E+04	-0.22036E+03	-0.75391E+01

XHAT	XDHAT	XDDHAT
0.99037E+04	-0.22103E+03	-0.75391E+01

Z	ZD	ZDD
0.97300E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.19230E+03	0.79735E+02	-0.75391E+01

Y= 0.97300E+04 (Y-XHAT) = -0.17073E+03

RESULTS FOR STEP 10

T	XBAR	XDBAR	XDDBAR
0.10000E+01	0.98815E+04	-0.22747E+03	-0.92605E+01

XHAT	YDHAT	XDDHAT
0.98537E+04	-0.22[illegible]E+03	-0.92605E+01

Z	ZD	ZDD
0.97000E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.18151E+03	0.72832E+02	-0.92605E+01

Y= 0.97000E+04 (Y-XHAT) = -0.15372E+03

RESULTS FOR STEP 11

T	XBAR	XDBAR	XDDBAR
0.11000E+01	0.96403E+04	-0.22436E+03	-0.39337E+01

XHAT	XDHAT	XDDHAT
0.98172E+04	-0.23525E+03	-0.39337E+01

Z	ZD	ZDD
0.96700E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAP-ZDD
0.17365E+03	0.65642E+02	-0.39337E+01

Y= 0.96700E+04 (Y-XHAT) = -0.14717E+03

RESULTS FOR STEP 12

T	XBAR	XDBAR	XDDBAR
0.12000E+01	0.93002E+04	-0.24094E+03	-0.95754E+01

XHAT	XDHAT	XDDHAT
0.97761E+04	-0.24190E+03	-0.95754E+01

Z	ZD	ZDD
0.96400E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAP-ZDD
0.16020E+03	0.59058E+02	-0.95754E+01

Y= 0.96400E+04 (Y-XHAT) = -0.13360E+03

RESULTS FOR STEP 13

T	XBAR	XDBAR	XDDBAR
0.13000E+01	0.97502E+04	-0.24724E+03	-0.10172E+02

XHAT	XDHAT	XDDHAT
0.97354E+04	-0.24320E+03	-0.10172E+02

Z	ZD	ZDD
0.96130E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.15015E+03	0.52762E+02	-0.10172E+02

Y= 0.96100E+04 (Y-XHAT) = -0.13530E+03

RESULTS FOR STEP 14

T	XBAR	XDBAR	XDDBAR
0.14000E+01	0.97205E+04	-0.25325E+03	-0.10731E+02

XHAT	XDHAT	XDDHAT
0.96951E+04	-0.25422E+03	-0.10731E+02

Z	ZD	ZDD
0.95800E+04	-0.33300E+03	0.33000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.14050E+03	0.46753E+02	-0.10731E+02

Y= 0.95600E+04 (Y-XHAT) = -0.11512E+03

RESULTS FOR STEP 15

T	XBAR	XDBAR	XDDBAR
0.15000E+01	0.96812E+04	-0.25698E+03	-0.11252E+02

XHAT	XDHAT	XDDHAT
0.96553E+04	-0.26011E+03	-0.11252E+02

Z	ZD	ZDD
0.95500E+04	-0.33000E+03	0.33000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.13122E+03	0.41017E+02	-0.11252E+02

Y= 0.95300E+04 (Y-XHAT) = -0.10527E+03

RESULTS FOR STEP 16

T	XBAR	XDBAR	XDDBAR
0.16000E+01	0.96423E+04	-0.26445E+03	-0.11738E+02

XHAT	XDHAT	XDDHAT
0.96153E+04	-0.26563E+03	-0.11738E+02

Z	ZD	ZDD
0.95200E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.12231E+03	0.35543E+02	-0.11738E+02

Y= 0.95200E+04 (Y-XHAT) = -0.95810E+02

RESULTS FOR STEP 17

T	XBAR	XDBAR	XDDBAR
0.17000E+01	0.96038E+04	-0.26967E+03	-0.12190E+02

XHAT	XDHAT	XDDHAT
0.95767E+04	-0.27089E+03	-0.12190E+02

Z	ZD	ZDD
0.94900E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.11375E+03	0.30329E+02	-0.12190E+02

Y= 0.94900E+04 (Y-XHAT) = -0.86733E+02

RESULTS FOR STEP 18

T	XBAR	XDBAR	XDDBAR
0.18000E+01	0.95659E+04	-0.27464E+03	-0.12610E+02

XHAT	XDHAT	XDDHAT
0.95533E+04	-0.27590E+03	-0.12610E+02

Z	ZD	ZDD
0.94600E+04	-0.30000E+03	0.00000E+00

```
XBAR - Z          XDBAR-ZD        XDDBAR-ZDD
 0.10555E+03    0.25359E+02    -0.12610E+02

Y=  0.94600E+04    (Y-XHAT) = -0.78026E+02
```

RESULTS FOR STEP 19

```
T                 XBAR            XDBAR           XDDBAR
0.19000E+01  0.95277E+04  -0.27937E+03 -0.12998E+02

XHAT              XDHAT           XDDHAT
0.94997E+04   -0.23047E+03   -0.12998E+02

Z                 ZD              ZDD
0.94300E+04   -0.30000E+03    0.00000E+00

XBAR - Z          XDBAR-ZD        XDDBAR-ZDD
 0.97561E+02    0.20027E+02   -0.12998E+02

Y=  0.94300E+04    (Y-XHAT) = -0.69578E+02
```

RESULTS FOR STEP 20

```
T                 XBAR            XDBAR           XDDBAR
0.20000E+01  0.94901E+04  -0.28381E+03 -0.13356E+02

XHAT              XDHAT           XDDHAT
0.94617E+04   -0.28521E+03   -0.13356E+02

Z                 ZD              ZDD
0.94300E+04   -0.30000E+03    0.00000E+00

XBAR - Z          XDBAR-ZD        XDDBAR-ZDD
 0.93132E+02    0.16183E+02   -0.13356E+02

Y=  0.94000E+04    (Y-XHAT) = -0.61673E+02
```

RESULTS FOR STEP 21

```
T                 XBAR            XDBAR           XDDBAR
0.21000E+01  0.94832E+04  -0.30516E+03 -0.13689E+02
```

```
XHAT            XDHAT           XDDHAT
0.94240E+04    -0.28953E+03    -0.13634E+02

Z               ZD              ZDD
0.93700E+04    -0.30000E+03     0.00000E+00

XBAR - Z        XDBAR-ZD        XDDBAR-ZDD
0.82697E+02     0.11843E+02    -0.13636E+02

Y=  0.93700E+04   (Y-XHAT) = -0.54014E+02
```

RESULTS FOR STEP 22

```
T               XBAR            XDBAR           XDDBAR
0.22000E+01   0.94150E+04    -0.29322E+03    -0.13938E+02

XHAT            XDHAT           XDDHAT
0.93367E+04    -0.29362E+03    -0.13988E+02

Z               ZD              ZDD
0.93400E+04    -0.30000E+03     0.00000E+00

XBAR - Z        XDBAR-ZD        XDDBAR-ZDD
0.75953E+02     0.77753E+01    -0.13938E+02

Y=  0.93400E+04   (Y-XHAT) = -0.46675E+02
```

RESULTS FOR STEP 23

```
T               XBAR            XDBAR           XDDBAR
0.23000E+01   0.93793E+04    -0.29803E+03    -0.14263E+02

XHAT            XDHAT           XDDHAT
0.93497E+04    -0.29751E+03    -0.14263E+02

Z               ZD              ZDD
0.93100E+04    -0.30000E+03     0.00000E+00

XBAR - Z        XDBAR-ZD        XDDBAR-ZDD
0.84332E+02     0.24810E+01    -0.14263E+02

Y=  0.93100E+04   (Y-XHAT) = -0.39694E+02
```

RESULTS FOR STEP 24

T	XBAR	XDBAR	XDDBAR
0.24000E+01	0.93430E+04	-0.29975E+03	-0.14913E+02

XHAT	XDHAT	XDDHAT
0.93129E+04	-0.30120E+03	-0.14513E+02

Z	ZD	ZDD
0.92800E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.62931E+02	0.24865E+00	-0.14513E+02

Y= 0.92500E+04 (Y-XHAT) = -0.32934E+02

RESULTS FOR STEP 25

T	XBAR	XDBAR	XDDBAR
0.25000E+01	0.93069E+04	-0.30322E+03	-0.14740E+02

XHAT	XDHAT	XDDHAT
0.92765E+04	-0.30470E+03	-0.14740E+02

Z	ZD	ZDD
0.92500E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.56906E+02	-0.32249E+01	-0.14740E+02

Y= 0.92500E+04 (Y-XHAT) = -0.26511E+02

RESULTS FOR STEP 26

T	XBAR	XDBAR	XDDBAR
0.26000E+01	0.92711E+04	-0.30651E+03	-0.14943E+02

XHAT	XDHAT	XDDHAT
0.92404E+04	-0.30201E+03	-0.14943E+02

Z	ZD	ZDD
0.92000E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.510995E+02	-0.65143E+01	-0.14943E+02

Y= 0.92300E+04 (Y-XHAT) = -0.20372E+02

RESULTS FOR STEP 27

T	XBAR	XDBAR	XDDBAR
0.27000E+01	0.92355E+04	-0.30963E+03	-0.15124E+02

XHAT	XDHAT	XDDHAT
0.92045E+04	-0.31114E+03	-0.15124E+02

Z	ZD	ZDD
0.91900E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.45548E+02	-0.96273E+01	-0.15124E+02

Y= 0.91900E+04 (Y-XHAT) = -0.14510E+02

RESULTS FOR STEP 28

T	XBAR	XDBAR	XDDBAR
0.28000E+01	0.92002E+04	-0.31357E+03	-0.15284E+02

XHAT	XDHAT	XDDHAT
0.91858E+04	-0.31410E+03	-0.15284E+02

Z	ZD	ZDD
0.91800E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.40247E+02	-0.13570E+02	-0.15284E+02

Y= 0.91800E+04 (Y-XHAT) = -0.39141E+01

RESULTS FOR STEP 29

T	XBAR	XDBAR	XDDBAR
0.29000E+01	0.91952E+04	-0.31535E+03	-0.15424E+02

XHAT	XDHAT	XDDHAT
0.91336E+04	-0.31[illegible]E+03	-0.15424E+02

Z	ZD	ZDD
0.91300E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.35138E+02	-0.15349E+02	-0.15424E+02

Y= 0.91300E+04 (Y-XHAT) = -0.35752E+01

RESULTS FOR STEP 30

T	XBAR	XDBAR	XDDBAR
0.30000E+01	0.91304E+04	-0.31797E+03	-0.15544E+02

XHAT	XDHAT	XDDHAT
0.90903E+04	-0.31952E+03	-0.15544E+02

Z	ZD	ZDD
0.91000E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.30359E+02	-0.17970E+02	-0.15544E+02

Y= 0.91300E+04 (Y-XHAT) = 0.15136E+01

RESULTS FOR STEP 31

T	XBAR	XDBAR	XDDBAR
0.31000E+01	0.90956E+04	-0.32044E+03	-0.15647E+02

XHAT	XDHAT	XDDHAT
0.90636E+04	-0.32200E+03	-0.15647E+02

Z	ZD	ZDD
0.90700E+04	-0.30000E+03	0.00000E+00

```
XBAR - Z          XDBAR-ZD        XDDBAR-ZDD
 0.25757E+02   -0.20439E+02    -0.15647E+02

Y=  0.90700E+04   (Y-XHAT) =  0.83652E+01
```

RESULTS FOR STEP 32

```
     T              XBAR           XDBAR          XDDBAR
 0.32000E+01  0.90814E+04  -0.32276E+03 -0.15731E+02

     XHAT           XDHAT          XDDHAT
 0.90290E+04  -0.32434E+03  -0.15731E+02

      Z              ZD             ZDD
 0.90400E+04  -0.30000E+03   0.00000E+00

XBAR - Z          XDBAR-ZD        XDDBAR-ZDD
 0.21371E+02   -0.22763E+02    -0.15731E+02

Y=  0.90400E+04   (Y-XHAT) =  0.10984E+02
```

RESULTS FOR STEP 33

```
     T              XBAR           XDBAR          XDDBAR
 0.33000E+01  0.90272E+04  -0.32495E+03 -0.15800E+02

     XHAT           XDHAT          XDDHAT
 0.89940E+04  -0.32653E+03  -0.15800E+02

      Z              ZD             ZDD
 0.90100E+04  -0.30000E+03   0.00000E+00

XBAR - Z          XDBAR-ZD        XDDBAR-ZDD
 0.17194E+02   -0.24946E+02    -0.15800E+02

Y=  0.90100E+04   (Y-XHAT) =  0.15330E+02
```

RESULTS FOR STEP 34

```
     T              XBAR           XDBAR          XDDBAR
 0.34000E+01  0.89732E+04  -0.32700E+03 -0.15868E+02
```

```
   XHAT              XDHAT             XDDHAT
0.39604E+04    -0.32553E+03    -0.15852E+02

      Z                ZD               ZDD
0.39800E+04    -0.30000E+03     0.00000E+00

XBAR - Z          XDBAR-ZD         XDDBAR-ZDD
0.13220E+02    -0.26997E+02    -0.15352E+02

Y=  0.39900E+04   (Y-XHAT) =  0.19500E+02
```

RESULTS FOR STEP 35

```
      T                XBAR             XDBAR            XDDBAR
0.35000E+01  0.39594E+04  -0.32892E+03 -0.15890E+02

   XHAT              XDHAT             XDDHAT
0.39206E+04    -0.33051E+03    -0.15890E+02

      Z                ZD               ZDD
0.39500E+04    -0.33000E+03     0.00000E+00

XBAR - Z          XDBAR-ZD         XDDBAR-ZDD
0.94404E+01    -0.28913E+02    -0.15890E+02

Y=  0.39900E+04   (Y-XHAT) =  0.23537E+02
```

RESULTS FOR STEP 34

```
      T                XBAR             XDBAR            XDDBAR
0.34000E+01  0.39259E+04  -0.33071E+03 -0.15913E+02

   XHAT              XDHAT             XDDHAT
0.39927E+04    -0.33231E+03    -0.15913E+02
```

Z	ZD	ZDD
0.39200E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.53500E+01	-0.30715E+02	-0.15913E+02

Y= 0.39200E+04 (Y-XHAT) = 0.27300E+02

RESULTS FOR STEP 37

T	XBAR	XDBAR	XDDBAR
0.37000E+01	0.38924E+04	-0.33239E+03	-0.15923E+02

XHAT	XDHAT	XDDHAT
0.38591E+04	-0.33399E+03	-0.15923E+02

Z	ZD	ZDD
0.38900E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
0.24414E+01	-0.32393E+02	-0.15923E+02

Y= 0.38900E+04 (Y-XHAT) = 0.30876E+02

RESULTS FOR STEP 38

T	XBAR	XDBAR	XDDBAR
0.38000E+01	0.38892E+04	-0.33396E+03	-0.15920E+02

XHAT	XDHAT	XDDHAT
0.38237E+04	-0.33553E+03	-0.15920E+02

Z	ZD	ZDD
0.38600E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.79492E+00	-0.33937E+02	-0.15920E+02

Y= 0.38600E+04 (Y-XHAT) = 0.36271E+02

RESULTS FOR STEP 39

T	XBAR	XDBAR	XDDBAR
0.39000E+01	0.38261E+04	-0.33541E+03	-0.15904E+02

XHAT	XDHAT	XDDHAT
0.37925E+04	-0.33700E+03	-0.15904E+02

Z	ZD	ZDD
0.38300E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.38613E+01	-0.35412E+02	-0.15904E+02

Y= 0.38300E+04 (Y-XHAT) = 0.37481E+02

RESULTS FOR STEP 40

T	XBAR	XDBAR	XDDBAR
0.40000E+01	0.37932E+04	-0.33675E+03	-0.15877E+02

XHAT	XDHAT	XDDHAT
0.37595E+04	-0.33835E+03	-0.15877E+02

Z	ZD	ZDD
0.38000E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.67645E+01	-0.38758E+02	-0.15877E+02

Y= 0.38000E+04 (Y-XHAT) = 0.40528E+02

RESULTS FOR STEP 41

T	XBAR	XDBAR	XDDBAR
0.41000E+01	0.37605E+04	-0.33801E+03	-0.15840E+02

XHAT	XDHAT	XDDHAT
0.37296E+04	-0.33960E+03	-0.15840E+02

Z	ZD	ZDD
0.37700E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.95117E+01	-0.33018E+02	-0.15340E+02

Y= 0.87700E+04 (Y-XHAT) = 0.43392E+02

RESULTS FOR STEP 42

T	XBAR	XDBAR	XDDBAR
0.42000E+01	0.87279E+04	-0.33917E+03	-0.15792E+02

XHAT	XDHAT	XDDHAT
0.86939E+04	-0.34074E+03	-0.15792E+02

Z	ZD	ZDD
0.87400E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.12109E+02	-0.39165E+02	-0.15792E+02

Y= 0.87400E+04 (Y-XHAT) = 0.46105E+02

RESULTS FOR STEP 43

T	XBAR	XDBAR	XDDBAR
0.43000E+01	0.86934E+04	-0.34023E+03	-0.15734E+02

XHAT	XDHAT	XDDHAT
0.85613E+04	-0.34100E+03	-0.15734E+02

Z	ZD	ZDD
0.87100E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.14563E+02	-0.40227E+02	-0.15734E+02

Y= 0.87100E+04 (Y-XHAT) = 0.48965E+02

RESULTS FOR STEP 44

T	XBAR	XDBAR	XDDBAR
0.44000E+01	0.86531E+04	-0.34120E+03	-0.15567E+02

```
   XHAT              XDHAT             XDDHAT
   0.86289E+04    -0.34277E+03    -0.15667E+02

    Z                 ZD                ZDD

    0.86000E+04     -0.30000E+03      0.00000E+00

  X2AR - Z          XDBAR-ZD          XDDBAR-ZDD
  -0.16878E+02    -0.41200E+02    -0.15667E+02

Y=  0.86600E+04   (Y-XHAT) =  0.51070E+02

          RESULTS FOR STEP  45

  T                 X3AR              XDBAR             XDDBAR
 0.45000E+01  0.86309E+04  -0.34209E+03 -0.15591E+02

   XHAT              XDHAT             XDDHAT
   0.86397E+04    -0.34365E+03    -0.15591E+02

    Z                 ZD                ZDD
    0.86500E+04     -0.30000E+03      0.00000E+00

  XBAR - Z          XDBAR-ZD          XDDBAR-ZDD
  -0.19358E+02    -0.42090E+02    -0.15591E+02

Y=  0.86500E+04   (Y-XHAT) =  0.53345E+02

          RESULTS FOR STEP  46

  T                 XBAR              XDBAR             XDDBAR
 0.46000E+01  0.86539E+04  -0.34200E+03 -0.15507E+02

   XHAT              XDHAT             XDDHAT
   0.85645E+04    -0.34445E+03    -0.15507E+02

    Z                 ZD                ZDD
    0.86200E+04     -0.30000E+03      0.00000E+00
```

```
   XBAR - Z          XDBAR-ZD          XDDBAR-ZDD
  -0.21139E+02     -0.42899E+02      -0.15507E+02

 Y=  0.26200E+04    (Y-XHAT) =  0.55477E+02
```

RESULTS FOR STEP 47

```
    T                 XBAR              XDBAR          XDDBAR
 0.47000E+01   0.25670E+04   -0.34363E+03 -0.15415E+02

    XHAT              XDHAT             XDDHAT
  0.25325E+04    -0.34517E+03      -0.15415E+02

     Z                 ZD                ZDD
  0.25700E+04     -0.30000E+03      0.00000E+00

   XBAR - Z          XDBAR-ZD          XDDBAR-ZDD
  -0.23037E+02     -0.43631E+02      -0.15415E+02

 Y=  0.25900E+04    (Y-XHAT) =  0.57473E+02
```

RESULTS FOR STEP 48

```
    T                 XBAR              XDBAR          XDDBAR
 0.48000E+01   0.25352E+04   -0.34429E+03 -0.15317E+02

    XHAT              XDHAT             XDDHAT
  0.25307E+04    -0.34543E+03      -0.15317E+02

     Z                 ZD                ZDD
  0.25600E+04     -0.30000E+03      0.00000E+00

   XBAR - Z          XDBAR-ZD          XDDBAR-ZDD
  -0.24046E+02     -0.44290E+02      -0.15317E+02

 Y=  0.25600E+04    (Y-XHAT) =  0.59351E+02
```

RESULTS FOR STEP 49

```
    T                 XBAR              XDBAR          XDDBAR
 0.49000E+01   0.25035E+04   -0.34472E+03 -0.15211E+02
```

```
   XHAT              XDHAT             XDDHAT
   0.34669E+04   -0.34644E+03   -0.15211E+02

    Z                 ZD                ZDD
   0.85300E+04   -0.30000E+03    0.00000E+00

 XBAR - Z          XDBAR-ZD          XDDBAR-ZDD
-0.26540E+02   -0.44876E+02   -0.15211E+02

Y=  0.85300E+04   (Y-XHAT) =  0.61104E+02

        RESULTS FOR STEP  50

  T                XBAR              XDBAR             XDDBAR
 0.50000E+01  0.34719E+04  -0.34840E+03  -0.15099E+02

   XHAT              XDHAT             XDDHAT

   0.34437E+04   -0.34691E+03   -0.15099E+02

    Z                 ZD                ZDD
   0.85000E+04   -0.30000E+03    0.00000E+00

 XBAR - Z          XDBAR-ZD          XDDBAR-ZDD
-0.28126E+02   -0.43400E+02   -0.15099E+02

Y=  0.85300E+04   (Y-XHAT) =  0.62741E+02

        RESULTS FOR STEP  51

  T                XBAR              XDBAR             XDDBAR
 0.51000E+01  0.34404E+04  -0.34816E+03  -0.14982E+02

   XHAT              XDHAT             XDDHAT
   0.34057E+04   -0.34736E+03   -0.14982E+02

    Z                 ZD                ZDD
   0.84700E+04   -0.30000E+03    0.00000E+00
```

```
XBAR - Z          XDBAR-ZD          XDDBAR-ZDD
-0.29605E+02    -0.45355E+02    -0.14942E+02

Y=  0.34700E+04    (Y-XHAT) =  0.64267E+02

          RESULTS FOR STEP  52

 T                XBAR              XDBAR          XDDBAR
0.52000E+01  0.34090E+04  -0.34624E+03 -0.14859E+02

  XHAT              XDHAT             XDDHAT
0.33743E+04    -0.34774E+03    -0.14859E+02

   Z                 ZD                ZDD
0.34400E+04     -0.30000E+03      0.00000E+00

XBAR - Z          XDBAR-ZD          XDDBAR-ZDD
-0.30985E+02    -0.46250E+02    -0.14859E+02

Y=  0.34400E+04    (Y-XHAT) =  0.65686E+02

          RESULTS FOR STEP  53

 T                XBAR              XDBAR          XDDBAR
0.53000E+01  0.33777E+04  -0.34659E+03 -0.14730E+02

  XHAT              XDHAT             XDDHAT
0.33430E+04    -0.34007E+03    -0.14730E+02

   Z                 ZD                ZDD
0.34100E+04     -0.30000E+03      0.00000E+00

XBAR - Z          XDBAR-ZD          XDDBAR-ZDD
-0.32269E+02    -0.46594E+02    -0.14730E+02

Y=  0.34100E+04    (Y-XHAT) =  0.67000E+02

          RESULTS FOR STEP  54

 T                XBAR              XDBAR          XDDBAR
0.54000E+01  0.33465E+04  -0.34636E+03 -0.14597E+02
```

XHAT	XDHAT	XDDHAT
0.93113E+04	-0.34934E+03	-0.14597E+02

Z	ZD	ZDD
0.33500E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.33457E+02	-0.46679E+02	-0.14597E+02

Y= 0.33500E+04 (Y-XHAT) = 0.43218E+02

RESULTS FOR STEP 55

T	XBAR	XDBAR	XDDBAR
0.55000E+01	0.93154E+04	-0.34711E+03	-0.14460E+02

XHAT	XDHAT	XDDHAT
0.82307E+04	-0.34653E+03	-0.14460E+02

Z	ZD	ZDD
0.83500E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.34593E+02	-0.47110E+02	-0.14460E+02

Y= 0.83500E+04 (Y-XHAT) = 0.59341E+02

RESULTS FOR STEP 56

T	XBAR	XDBAR	XDDBAR
0.56000E+01	0.93244E+04	-0.34728E+03	-0.14319E+02

XHAT	XDHAT	XDDHAT
0.32496E+04	-0.34872E+03	-0.14319E+02

Z	ZD	ZDD
0.83200E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.35573E+02	-0.47283E+02	-0.14319E+02

Y= 0.83200E+04 (Y-XHAT) = 0.70374E+02

RESULTS FOR STEP 57

T	XBAR	XDBAR	XDDBAR
0.57000E+01	0.82535E+04	-0.34743E+03	-0.14174E+02

XHAT	XDHAT	XDDHAT
0.82137E+04	-0.34884E+03	-0.14174E+02

Z	ZD	ZDD
0.82900E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.36503E+02	-0.47437E+02	-0.14174E+02

Y= 0.82900E+04 (Y-XHAT) = 0.71322E+02

RESULTS FOR STEP 58

T	XBAR	XDBAR	XDDBAR
0.58000E+01	0.82326E+04	-0.34750E+03	-0.14025E+02

XHAT	XDHAT	XDDHAT
0.82137E+04	-0.34892E+03	-0.14025E+02

Z	ZD	ZDD
0.82600E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.27365E+02	-0.47917E+02	-0.14025E+02

Y= 0.82600E+04 (Y-XHAT) = 0.72163E+02

RESULTS FOR STEP 59

T	XBAR	XDBAR	XDDBAR
0.59000E+01	0.81719E+04	-0.34756E+03	-0.13873E+02

XHAT	XDHAT	XDDHAT
0.81570E+04	-0.34695E+03	-0.13873E+02

Z	ZD	ZDD
0.82300E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.38147E+02	-0.47564E+02	-0.13873E+02

Y= 0.82300E+04 (Y-XHAT) = 0.72973E+02

RESULTS FOR STEP 60

T	XBAR	XDBAR	XDDBAR
0.60000E+01	0.81611E+04	-0.34757E+03	-0.13719E+02

XHAT	XDHAT	XDDHAT
0.81263E+04	-0.34794E+03	-0.13719E+02

Z	ZD	ZDD
0.82000E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.33557E+02	-0.47573E+02	-0.13719E+02

Y= 0.82000E+04 (Y-XHAT) = 0.73663E+02

RESULTS FOR STEP 61

T	XBAR	XDBAR	XDDBAR
0.61000E+01	0.81303E+04	-0.34754E+03	-0.13562E+02

XHAT	XDHAT	XDDHAT
0.80957E+04	-0.34638E+03	-0.13562E+02

```
     Z                    ZD                   ZDD
  0.81700E+04     -0.30000E+03      0.00000E+00

 XBAR - Z           XDBAR-ZD         XDDBAR-ZDD
-0.29499E+02    -0.47533E+02    -0.13562E+02

Y=  0.81700E+04   (Y-XHAT) =  0.74321E+02

          RESULTS FOR STEP  52

  T                 XBAR              XDBAR          XDDBAR
 0.62000E+01  0.80999E+04  -0.34747E+03 -0.13403E+02

   XHAT              XDHAT             XDDHAT
 0.80681E+04    -0.34181E+03    -0.13403E+02

     Z                    ZD                   ZDD
  0.81400E+04     -0.30000E+03      0.00000E+00

 XBAR - Z           XDBAR-ZD         XDDBAR-ZDD
-0.40076E+02    -0.47471E+02    -0.13403E+02

Y=  0.81400E+04   (Y-XHAT) =  0.74099E+02

          RESULTS FOR STEP  53

  T                 XBAR              XDBAR          XDDBAR
 0.63000E+01  0.80994E+04  -0.34737E+03 -0.13241E+02

   XHAT              XDHAT             XDDHAT
 0.80944E+04    -0.34169E+03    -0.13241E+02

     Z                    ZD                   ZDD
  0.81100E+04     -0.30000E+03      0.00000E+00

 XBAR - Z           XDBAR-ZD         XDDBAR-ZDD
-0.40591E+02    -0.47361E+02    -0.13241E+02

Y=  0.81100E+04   (Y-XHAT) =  0.75594E+02
```

RESULTS FOR STEP 64

T	XBAR	XDBAR	XDDBAR
0.64000E+01	0.80390E+04	-0.34723E+03	-0.13078E+02

XHAT	XDHAT	XDDHAT
0.80042E+04	-0.34654E+03	-0.13078E+02

Z	ZD	ZDD
0.80000E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.41047E+02	-0.47234E+02	-0.13078E+02

Y= 0.80000E+04 (Y-XHAT) = -0.75336E+02

RESULTS FOR STEP 65

T	XBAR	XDBAR	XDDBAR
0.65000E+01	0.80036E+04	-0.34707E+03	-0.12914E+02

XHAT	XDHAT	XDDHAT
0.79733E+04	-0.34335E+03	-0.12914E+02

Z	ZD	ZDD
0.80500E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.41446E+02	-0.47065E+02	-0.12914E+02

Y= 0.80500E+04 (Y-XHAT) = 0.76013E+02

RESULTS FOR STEP 66

T	XBAR	XDBAR	XDDBAR
0.66000E+01	0.79782E+04	-0.34598E+03	-0.12747E+02

XHAT	XDHAT	XDDHAT
0.79435E+04	-0.34019E+03	-0.12747E+02

Z	ZD	ZDD
0.80200E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.41792E+02	-0.46675E+02	-0.12747E+02

Y= 0.80200E+04 (Y-XHAT) = 0.76543E+02

RESULTS FOR STEP 67

T	XBAR	XDBAR	XDDBAR
0.67000E+01	0.79479E+04	-0.34885E+03	-0.12580E+02

XHAT	XDHAT	XDDHAT
0.79132E+04	-0.34791E+03	-0.12500E+02

Z	ZD	ZDD
0.79900E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.42066E+02	-0.46655E+02	-0.12580E+02

Y= 0.79900E+04 (Y-XHAT) = 0.76814E+02

RESULTS FOR STEP 68

T	XBAR	XDBAR	XDDBAR
0.68000E+01	0.79177E+04	-0.34941E+03	-0.12612E+02

XHAT	XDHAT	XDDHAT
0.79133E+04	-0.34795E+03	-0.12612E+02

Z	ZD	ZDD
0.79300E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.42331E+02	-0.46409E+02	-0.12612E+02

Y= 0.79300E+04 (Y-XHAT) = 0.77074E+02

RESULTS FOR STEP 69

T	XBAR	XDBAR	XDDBAR
0.69000E+01	0.78875E+04	-0.34614E+03	-0.12243E+02

XHAT	XDHAT	XDDHAT
0.78528E+04	-0.34730E+03	-0.12243E+02

Z	ZD	ZDD
0.79300E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.42529E+02	-0.46139E+02	-0.12243E+02

Y= 0.79300E+04 (Y-XHAT) = 0.77204E+02

RESULTS FOR STEP 70

T	XBAR	XDBAR	XDDBAR
0.70000E+01	0.78573E+04	-0.34535E+03	-0.12073E+02

XHAT	XDHAT	XDDHAT
0.78227E+04	-0.34705E+03	-0.12073E+02

Z	ZD	ZDD
0.79000E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.42734E+02	-0.46464E+02	-0.12073E+02

Y= 0.79000E+04 (Y-XHAT) = 0.77234E+02

RESULTS FOR STEP 71

T	XBAR	XDBAR	XDDBAR
0.71000E+01	0.78272E+04	-0.34553E+03	-0.11903E+02

XHAT	XDHAT	XDDHAT
0.77930E+04	-0.34672E+03	-0.11903E+02

```
          Z                    ZD                   ZDD
     0.73700E+04     -0.30000E+03      0.00000E+00

  XBAR - Z            XDBAR-ZD          XDDBAR-ZDD
-0.42796E+02     -0.45533E+02      -0.11900E+02

Y=  0.73700E+04   (Y-XHAT) =  0.77409E+02
```

RESULTS FOR STEP 72

```
          T                 XBAR                 XDBAR               XDDBAR
 0.72000E+01   0.77971E+04   -0.34520E+03  -0.11733E+02

        XHAT                 XDHAT                XDDHAT
     0.77626E+04     -0.34637E+03      -0.11737E+02

          Z                    ZD                   ZDD
     0.73400E+04     -0.30000E+03      0.00000E+00

  XBAR - Z            XDBAR-ZD          XDDBAR-ZDD
-0.42869E+02     -0.45200E+02      -0.11703E+02

Y=  0.73400E+04   (Y-XHAT) =  0.77447E+02
```

RESULTS FOR STEP 73

```
          T                 XDAR                 XDBAR               XDDBAR
 0.73000E+01   0.77671E+04   -0.34475E+03  -0.11562E+02

        XHAT                 XDHAT                XDDHAT
     0.77326E+04     -0.34600E+03      -0.11562E+02

          Z                    ZD                   ZDD
     0.73100E+04     -0.30000E+03      0.00000E+00

  XBAR - Z            XDBAR-ZD          XDDBAR-ZDD
-0.42903E+02     -0.44049E+02      -0.11582E+02

Y=  0.73100E+04   (Y-XHAT) =  0.77446E+02
```

RESULTS FOR STEP 74

T	XBAR	XDBAR	XDDBAR
0.74000E+01	0.77371E+04	-0.34442E+03	-0.11392E+02

XHAT	XDHAT	XDDHAT
0.77026E+04	-0.34562E+03	-0.11392E+02

Z	ZD	ZDD
0.77000E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.42902E+02	-0.44442E+02	-0.11392E+02

Y= 0.77000E+04 (Y-XHAT) = 0.77407E+02

RESULTS FOR STEP 75

T	XBAR	XDBAR	XDDBAR
0.75000E+01	0.77371E+04	-0.34410E+03	-0.11221E+02

XHAT	XDHAT	XDDHAT
0.76727E+04	-0.34522E+03	-0.11221E+02

Z	ZD	ZDD
0.77500E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.42867E+02	-0.44098E+02	-0.11221E+02

Y= 0.77500E+04 (Y-XHAT) = 0.77338E+02

RESULTS FOR STEP 76

T	XBAR	XDBAR	XDDBAR
0.76000E+01	0.76772E+04	-0.34370E+03	-0.11051E+02

XHAT	XDHAT	XDDHAT
0.76423E+04	-0.34483E+03	-0.11051E+02

```
      Z                    ZD                   ZDD
  0.77200E+04     -0.30000E+03       0.00000E+00

  XBAR - Z           XDBAR-ZD         XDDBAR-ZDD
 -0.42300E+02    -0.43695E+02     -0.11051E+02

Y=  0.77200E+04   (Y-XHAT) =  0.77225E+02

          RESULTS FOR STEP  77

  T                 XBAR              XDBAR          XDDBAR
 0.77000E+01  0.76473E+04  -0.34329E+03 -0.10992E+02

    XHAT              XDHAT             XDDHAT
  0.76129E+04    -0.34437E+03      -0.10980E+02

      Z                    ZD                   ZDD
  0.76900E+04     -0.30000E+03       0.00000E+00

  XBAR - Z           XDBAR-ZD         XDDBAR-ZDD
 -0.42702E+02    -0.43005E+02     -0.10992E+02

Y=  0.76900E+04   (Y-XHAT) =  0.77095E+02

          RESULTS FOR STEP  78

  T                 XBAR              XDBAR          XDDBAR
 0.78000E+01  0.76174E+04  -0.34236E+03 -0.10712E+02

    XHAT              XDHAT             XDDHAT
  0.75931E+04    -0.34098E+03      -0.10712E+02

      Z                    ZD                   ZDD
  0.75600E+04     -0.30000E+03       0.00000E+00

  XBAR - Z           XDBAR-ZD         XDDBAR-ZDD
 -0.42576E+02    -0.42961E+02     -0.10712E+02

Y=  0.75600E+04   (Y-XHAT) =  0.76916E+02
```

RESULTS FOR STEP 79

T	XBAR	XDBAR	XDDBAR
0.79000E+01	0.75575E+04	-0.34242E+03	-0.10544E+02

XHAT	XDHAT	XDDHAT
0.75533E+04	-0.34343E+03	-0.10544E+02

Z	ZD	ZDD
0.76300E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.42422E+02	-0.42424E+02	-0.10544E+02

Y= 0.76300E+04 (Y-XHAT) = 0.76713E+02

RESULTS FOR STEP 80

T	XBAR	XDBAR	XDDBAR
0.80000E+01	0.75578E+04	-0.34198E+03	-0.10376E+02

XHAT	XDHAT	XDDHAT
0.75235E+04	-0.34300E+03	-0.10376E+02

Z	ZD	ZDD
0.76000E+04	-0.30000E+03	0.00000E+00

XBAR - Z	XDBAR-ZD	XDDBAR-ZDD
-0.42244E+02	-0.41978E+02	-0.10376E+02

Y= 0.76000E+04 (Y-XHAT) = 0.76469E+02

TABLE 2. Tabular Summation

```
                                INPUT SECTION
**********************************************************************************
        NAME OF OUTPUT IS DISP VECTOR (NO NOISE, NO MANEUVER) - BETA = .967
        SEED FOR THIS RUN IS     1

             XBAR= 10270.00 XDBAR= -0.15000E+03 XDDBAR=  0.00000E+00

              NOISE FACTOR IS    0.00 MEAN IS    0.00

              Z1= 0.10000E+05 ZD1= -0.30000E+03 ZDD=  0.00000E+00

              IMAX=  80

              T=    0.00 DELT=    0.10 TM=    10.00
**********************************************************************************
```

STEP	Z	XBAR	ZD	XDBAR	ZDD	XDDBAR
1	0.99700E+04	0.10270E+05	-0.30000E+03	-0.15000E+03	0.00000E+00	0.00000E+00
2	0.99400E+04	0.10225E+05	-0.30000E+03	-0.16012E+03	0.00000E+00	-0.11320E+01
3	0.99100E+04	0.10180E+05	-0.30000E+03	-0.16984E+03	0.00000E+00	-0.22059E+01
4	0.98800E+04	0.10136E+05	-0.30000E+03	-0.17916E+03	0.00000E+00	-0.32236E+01
5	0.98500E+04	0.10092E+05	-0.30000E+03	-0.18809E+03	0.00000E+00	-0.41873E+01
6	0.98200E+04	0.10049E+05	-0.30000E+03	-0.19666E+03	0.00000E+00	-0.50988E+01
7	0.97900E+04	0.10007E+05	-0.30000E+03	-0.20487E+03	0.00000E+00	-0.59600E+01
8	0.97600E+04	0.99645E+04	-0.30000E+03	-0.21274E+03	0.00000E+00	-0.67729E+01
9	0.97300E+04	0.99223E+04	-0.30000E+03	-0.22026E+03	0.00000E+00	-0.75391E+01
10	0.97000E+04	0.98815E+04	-0.30000E+03	-0.22747E+03	0.00000E+00	-0.82605E+01
11	0.96700E+04	0.98423E+04	-0.30000E+03	-0.23436E+03	0.00000E+00	-0.89387E+01
12	0.96400E+04	0.98046E+04	-0.30000E+03	-0.24094E+03	0.00000E+00	-0.95754E+01

STEP	Z	XBAR	ZD	XDBAR	ZDD	XDDBAR
13	0.96100E+04	0.97602E+04	-0.30000E+03	-0.24724E+03	0.00000E+00	-0.10172E+02
14	0.95800E+04	0.97205E+04	-0.30000E+03	-0.25325E+03	0.00000E+00	-0.10731E+02
15	0.95500E+04	0.96812E+04	-0.30000E+03	-0.25898E+03	0.00000E+00	-0.11252E+02
16	0.95200E+04	0.96423E+04	-0.30000E+03	-0.26445E+03	0.00000E+00	-0.11738E+02
17	0.94900E+04	0.96038E+04	-0.30000E+03	-0.26967E+03	0.00000E+00	-0.12190E+02
18	0.94600E+04	0.95656E+04	-0.30000E+03	-0.27464E+03	0.00000E+00	-0.12610E+02
19	0.94300E+04	0.95277E+04	-0.30000E+03	-0.27937E+03	0.00000E+00	-0.12998E+02
20	0.94000E+04	0.94901E+04	-0.30000E+03	-0.28388E+03	0.00000E+00	-0.13356E+02
21	0.93700E+04	0.94529E+04	-0.30000E+03	-0.28816E+03	0.00000E+00	-0.13686E+02
22	0.93400E+04	0.94160E+04	-0.30000E+03	-0.29222E+03	0.00000E+00	-0.13986E+02
23	0.93100E+04	0.93793E+04	-0.30000E+03	-0.29609E+03	0.00000E+00	-0.14263E+02
24	0.92300E+04	0.93430E+04	-0.30000E+03	-0.29975E+03	0.00000E+00	-0.14513E+02
25	0.92500E+04	0.93069E+04	-0.30000E+03	-0.30322E+03	0.00000E+00	-0.14740E+02

STEP	Z	XBAR	ZD	XDBAR	ZDD	XDDBAR
26	0.92200E+04	0.92711E+04	-0.30000E+03	-0.30651E+03	0.00000E+00	-0.14943E+02
27	0.91900E+04	0.92355E+04	-0.30000E+03	-0.30963E+03	0.00000E+00	-0.15124E+02
28	0.91600E+04	0.92002E+04	-0.30000E+03	-0.31257E+03	0.00000E+00	-0.15284E+02
29	0.91300E+04	0.91652E+04	-0.30000E+03	-0.31535E+03	0.00000E+00	-0.15424E+02
30	0.91000E+04	0.91304E+04	-0.30000E+03	-0.31797E+03	0.00000E+00	-0.15544E+02
31	0.90700E+04	0.90959E+04	-0.30000E+03	-0.32044E+03	0.00000E+00	-0.15647E+02
32	0.90400E+04	0.90614E+04	-0.30000E+03	-0.32276E+03	0.00000E+00	-0.15731E+02
33	0.90100E+04	0.90272E+04	-0.30000E+03	-0.32495E+03	0.00000E+00	-0.15800E+02
34	0.89800E+04	0.89932E+04	-0.30000E+03	-0.32700E+03	0.00000E+00	-0.15852E+02
35	0.89500E+04	0.89594E+04	-0.30000E+03	-0.32892E+03	0.00000E+00	-0.15890E+02
36	0.89200E+04	0.89259E+04	-0.30000E+03	-0.33071E+03	0.00000E+00	-0.15913E+02
37	0.88900E+04	0.88926E+04	-0.30000E+03	-0.33239E+03	0.00000E+00	-0.15923E+02

STEP	Z	XBAR	ZD	XDBAR	ZDD	XDDBAR
38	0.88600E+04	0.88592E+04	-0.30000E+03	-0.33396E+03	0.00000E+00	-0.15920E+02
39	0.88300E+04	0.88261E+04	-0.30000E+03	-0.33541E+03	0.00000E+00	-0.15904E+02
40	0.88000E+04	0.87932E+04	-0.30000E+03	-0.33676E+03	0.00000E+00	-0.15877E+02
41	0.87700E+04	0.87605E+04	-0.30000E+03	-0.33801E+03	0.00000E+00	-0.15840E+02
42	0.87400E+04	0.87279E+04	-0.30000E+03	-0.33917E+03	0.00000E+00	-0.15792E+02
43	0.87100E+04	0.86954E+04	-0.30000E+03	-0.34023E+03	0.00000E+00	-0.15734E+02
44	0.86800E+04	0.86631E+04	-0.30000E+03	-0.34120E+03	0.00000E+00	-0.15667E+02
45	0.86500E+04	0.86309E+04	-0.30000E+03	-0.34209E+03	0.00000E+00	-0.15591E+02
46	0.86200E+04	0.85989E+04	-0.30000E+03	-0.34290E+03	0.00000E+00	-0.15507E+02
47	0.85900E+04	0.85670E+04	-0.30000E+03	-0.34363E+03	0.00000E+00	-0.15415E+02
48	0.85600E+04	0.85352E+04	-0.30000E+03	-0.34429E+03	0.00000E+00	-0.15317E+02
49	0.85300E+04	0.85036E+04	-0.30000E+03	-0.34489E+03	0.00000E+00	-0.15211E+02
50	0.85000E+04	0.84721E+04	-0.30000E+03	-0.34540E+03	0.00000E+00	-0.15099E+02

STEP	Z	XBAR	ZD	XDBAR	XDD	XDDBAR
51	0.84700E+04	0.84404E+04	-0.30000E+03	-0.34536E+03	0.00000E+00	-0.14982E+02
52	0.84400E+04	0.84090E+04	-0.30000E+03	-0.34626E+03	0.00000E+00	-0.14859E+02
53	0.84100E+04	0.83777E+04	-0.30000E+03	-0.34659E+03	0.00000E+00	-0.14730E+02
54	0.83800E+04	0.83465E+04	-0.30000E+03	-0.34689E+03	0.00000E+00	-0.14597E+02
55	0.83500E+04	0.83154E+04	-0.30000E+03	-0.34711E+03	0.00000E+00	-0.14460E+02
56	0.83200E+04	0.82844E+04	-0.30000E+03	-0.34729E+03	0.00000E+00	-0.14319E+02
57	0.82900E+04	0.82535E+04	-0.30000E+03	-0.34743E+03	0.00000E+00	-0.14174E+02
58	0.82600E+04	0.82226E+04	-0.30000E+03	-0.34752E+03	0.00000E+00	-0.14025E+02
59	0.82300E+04	0.81919E+04	-0.30000E+03	-0.34756E+03	0.00000E+00	-0.13873E+02
60	0.82000E+04	0.81611E+04	-0.30000E+03	-0.34757E+03	0.00000E+00	-0.13719E+02
61	0.81700E+04	0.81306E+04	-0.30000E+03	-0.34754E+03	0.00000E+00	-0.13562E+02
62	0.81400E+04	0.81000E+04	-0.30000E+03	-0.34747E+03	0.00000E+00	-0.13403E+02
63	0.81100E+04	0.80695E+04	-0.30000E+03	-0.34737E+03	0.00000E+00	-0.13241E+02

STEP	Z	XBAR	ZD	XDBAR	ZDD	XDDBAR
64	0.80800E+04	0.80390E+04	-0.30000E+03	-0.34723E+03	0.00000E+00	-0.13078E+02
65	0.80500E+04	0.80088E+04	-0.30000E+03	-0.34707E+03	0.00000E+00	-0.12914E+02
66	0.80200E+04	0.79792E+04	-0.30000E+03	-0.34688E+03	0.00000E+00	-0.12747E+02
67	0.79900E+04	0.79479E+04	-0.30000E+03	-0.34665E+03	0.00000E+00	-0.12580E+02
68	0.79600E+04	0.79177E+04	-0.30000E+03	-0.34641E+03	0.00000E+00	-0.12412E+02
69	0.79300E+04	0.78875E+04	-0.30000E+03	-0.34614E+03	0.00000E+00	-0.12243E+02
70	0.79000E+04	0.78573E+04	-0.30000E+03	-0.34585E+03	0.00000E+00	-0.12073E+02
71	0.78700E+04	0.78272E+04	-0.30000E+03	-0.34553E+03	0.00000E+00	-0.11903E+02
72	0.78400E+04	0.77971E+04	-0.30000E+03	-0.34520E+03	0.00000E+00	-0.11733E+02
73	0.78100E+04	0.77671E+04	-0.30000E+03	-0.34485E+03	0.00000E+00	-0.11562E+02
74	0.77800E+04	0.77371E+04	-0.30000E+03	-0.34443E+03	0.00000E+00	-0.11392E+02
75	0.77500E+04	0.77071E+04	-0.30000E+03	-0.34410E+03	0.00000E+00	-0.11221E+02

STEP	Z	XBAR	ZD°	XDBAR	ZDD	XDDBAR
76	0.77200E+04	0.76772E+04	-0.30000E+03	-0.34370E+03	0.00000E+00	-0.11051E+02
77	0.77900E+04	0.76473E+04	-0.30000E+03	-0.34329E+03	0.00000E+00	-0.10882E+02
78	0.76600E+04	0.76174E+04	-0.30000E+03	-0.34286E+03	0.00000E+00	-0.10712E+02
79	0.76300E+04	0.75876E+04	-0.30000E+03	-0.34242E+03	0.00000E+00	-0.10544E+02
80	0.76000E+04	0.75575E+04	-0.30000E+03	-0.34198E+03	0.00000E+00	-0.10376E+02

END OF JOB FOR PROGRAM DISP VECTOR (NO NOISE, NO MANEUVER) - BETA = .967

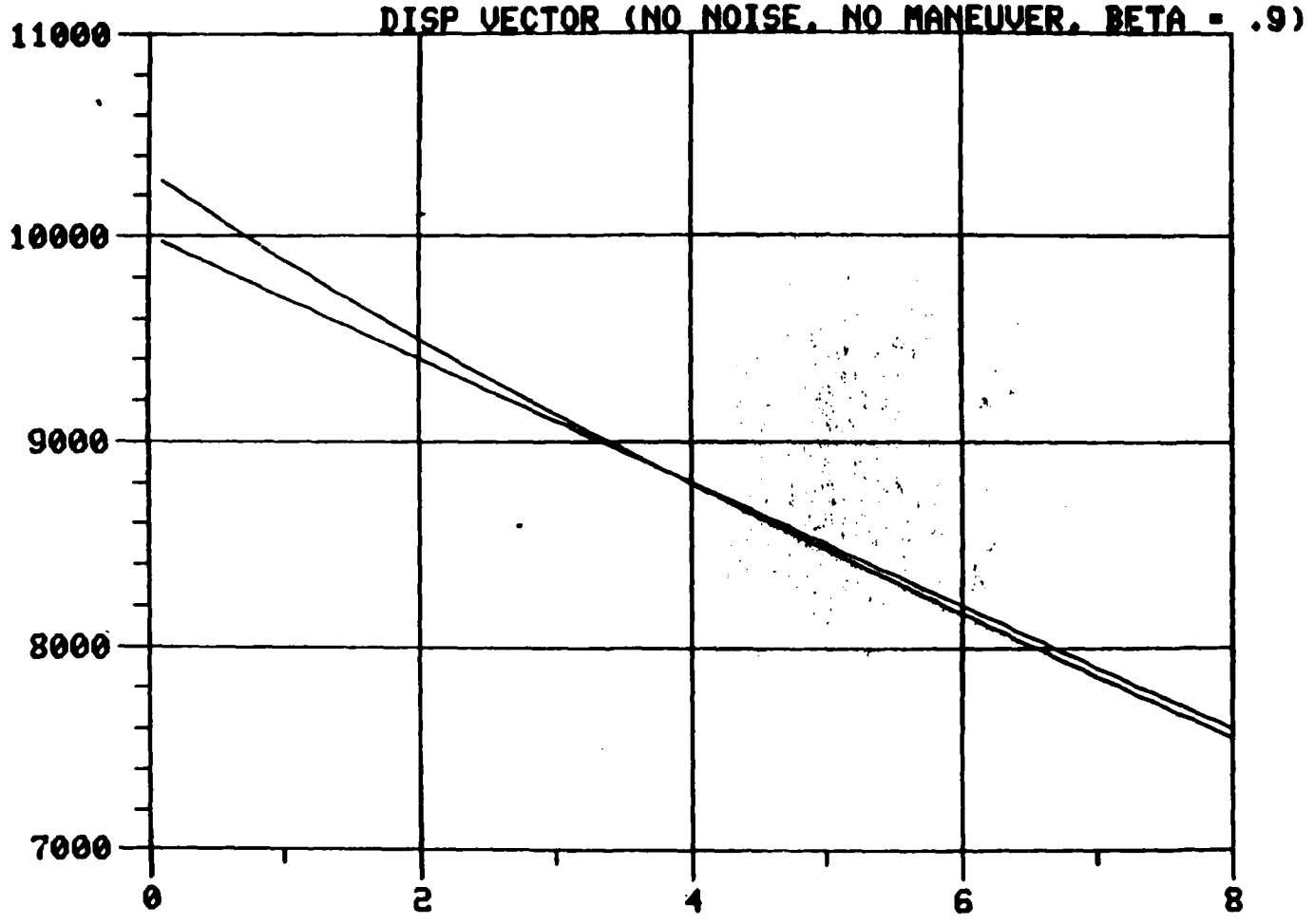

DISP VECTOR (NO NOISE, NO MANEUVER, BETA = .9)
11000
10000
9000
8000
7000
0
2
4
6
8

Figure 1

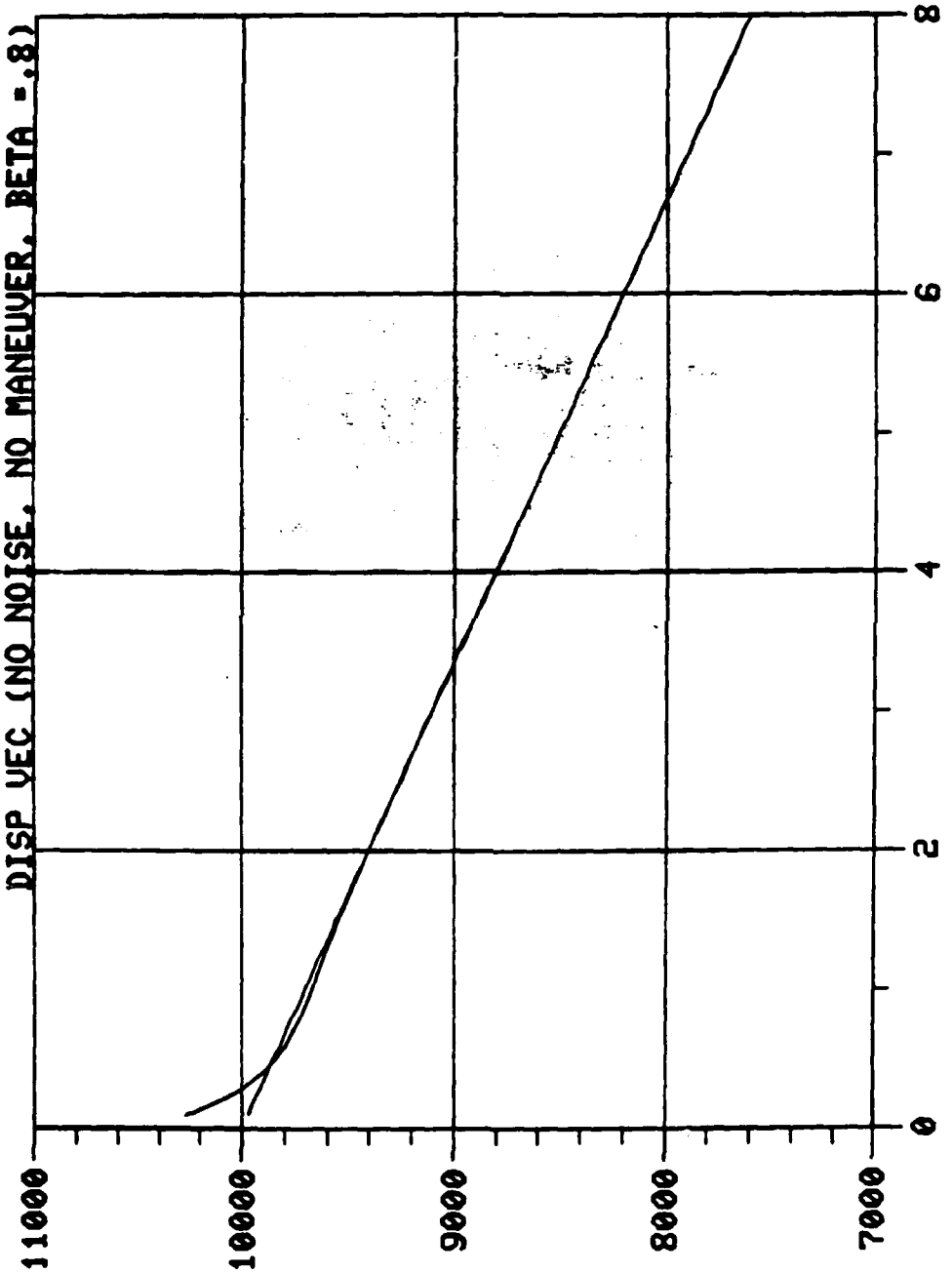

DISP VEC (NO NOISE, NO MANEUVER, BETA = .8)
11000
10000
9000
8000
7000
0
2
4
6
8

Figure 2

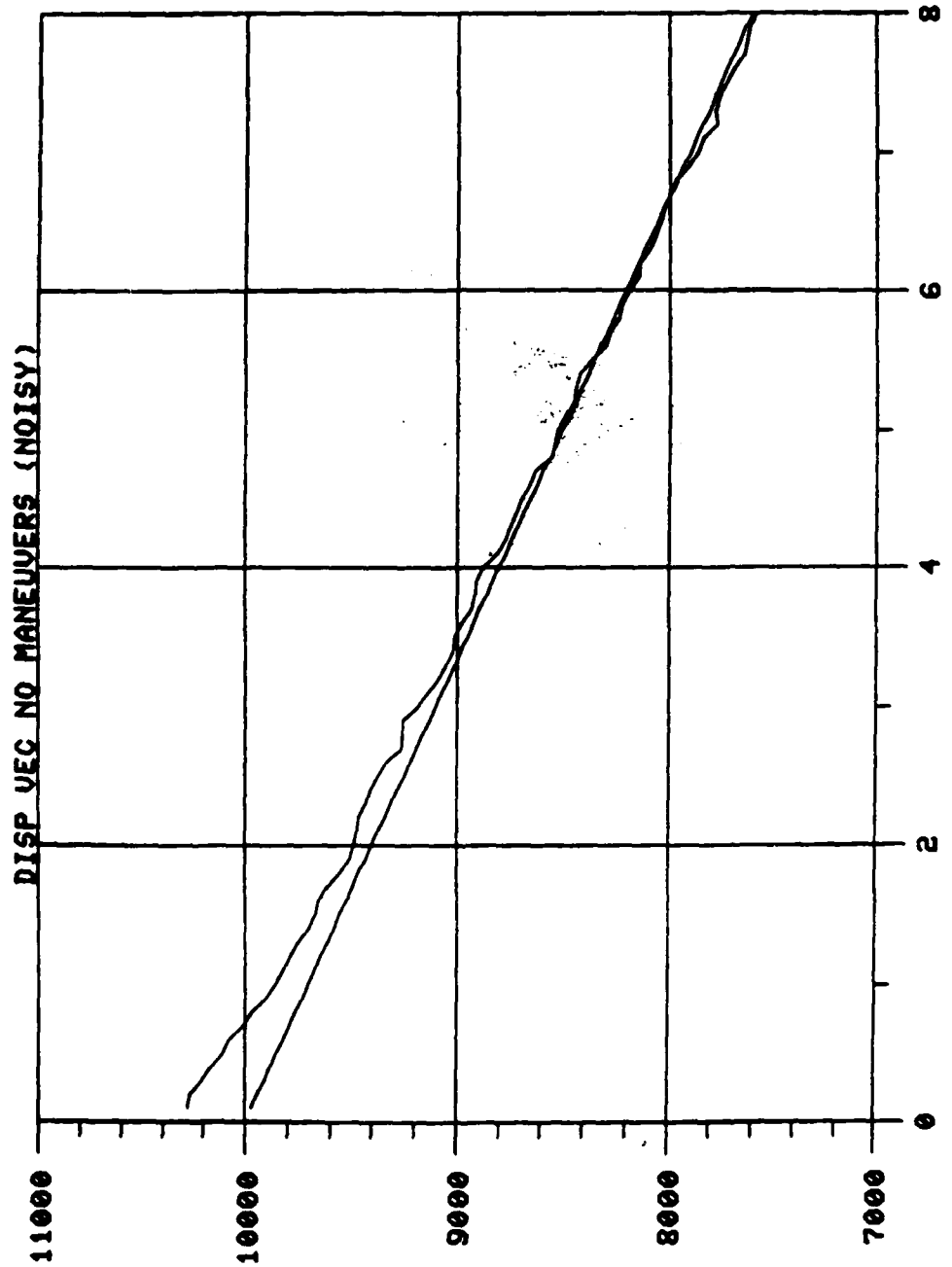

DISP VEC NO MANEUVERS (NOISY)
11000
10000
9000
8000
7000
0
2
4
6
8

Figure 3

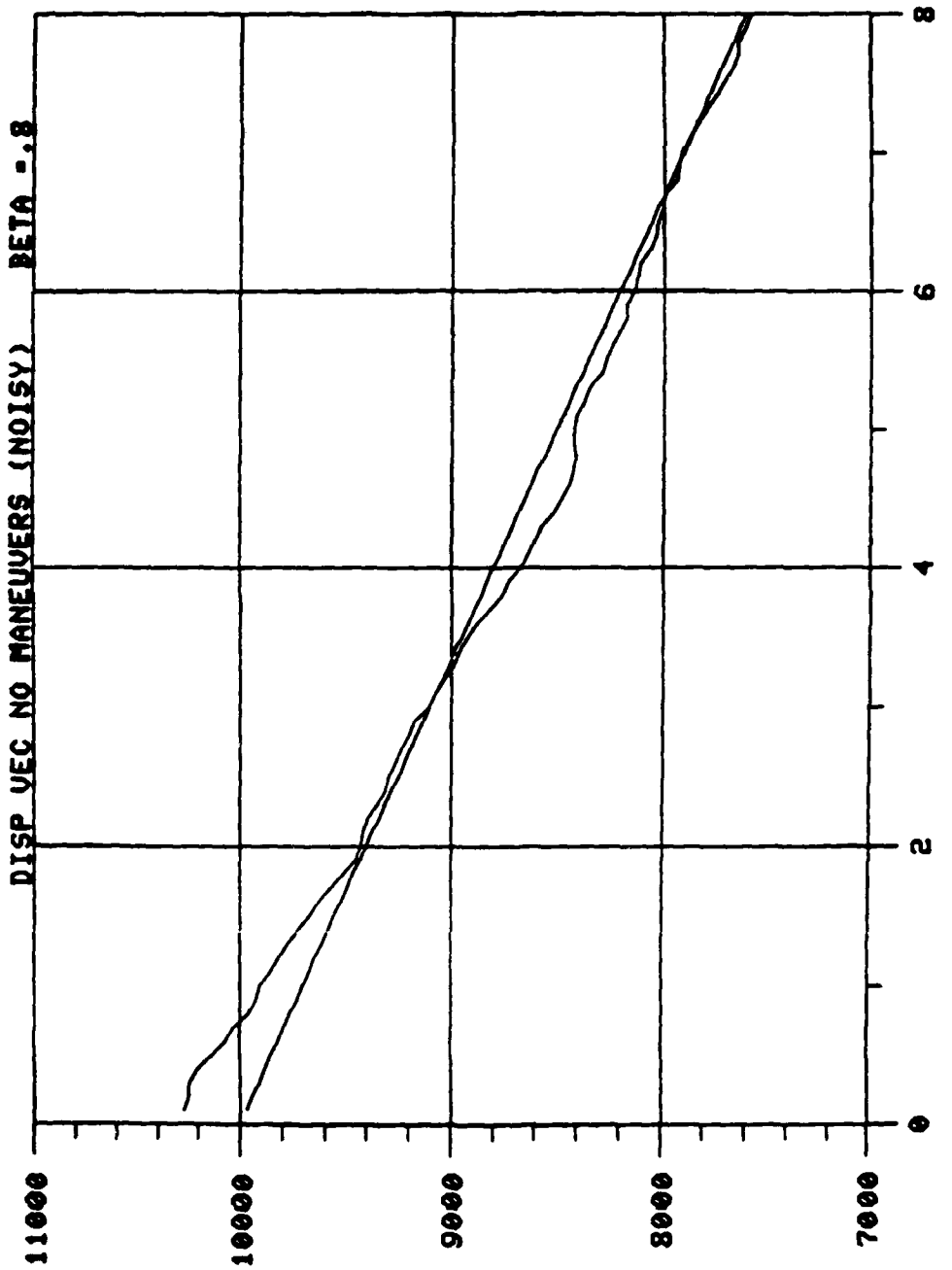

DISP VEC NO MANEUVERS (NOISY) BETA =.8
11000
10000
9000
8000
7000
0
2
4
6
8

Figure 4

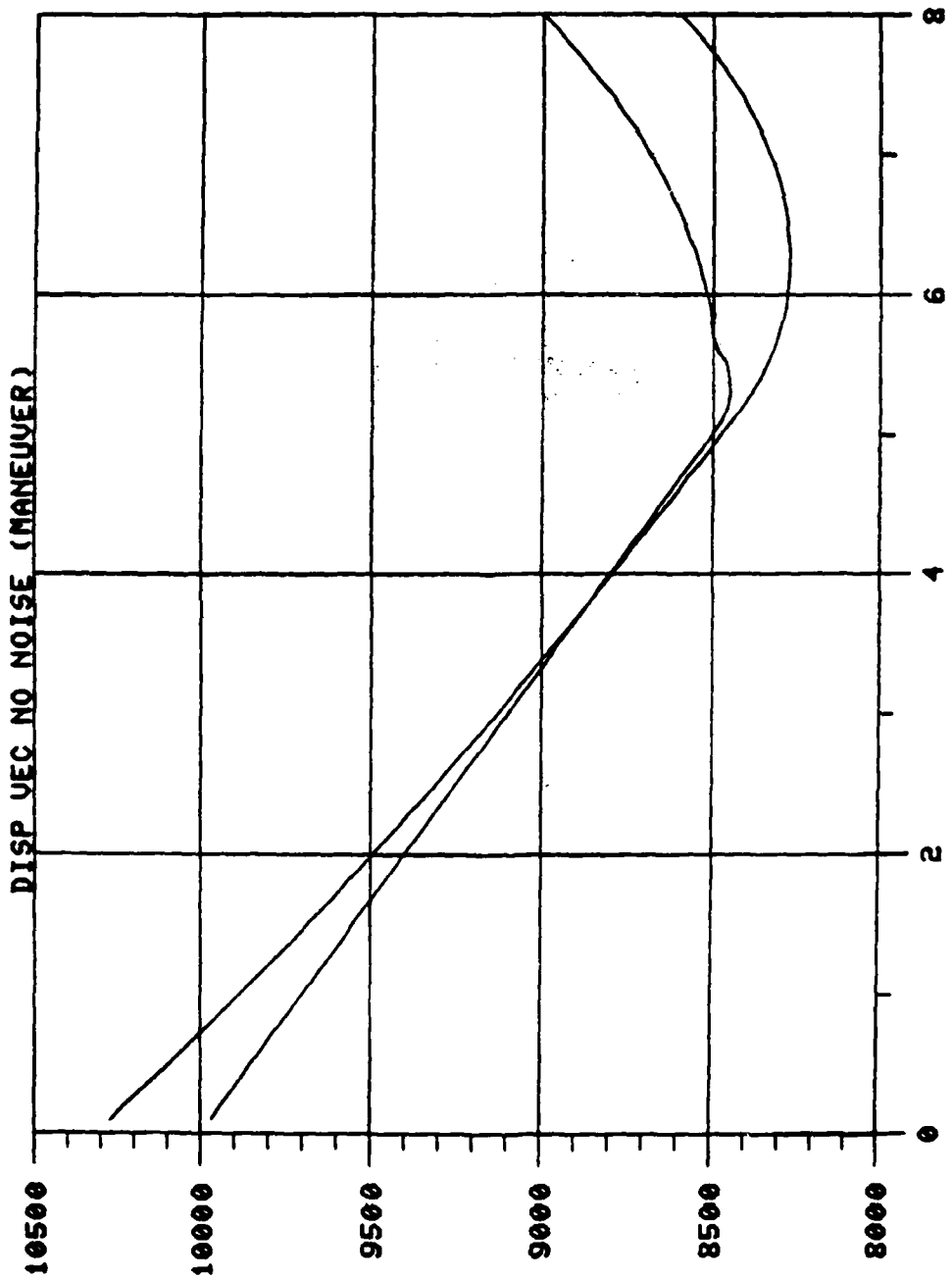

DISP VEC NO NOISE (MANEUVER)
10500
10000
9500
9000
8500
8000
0
2
4
6
8

Figure 5

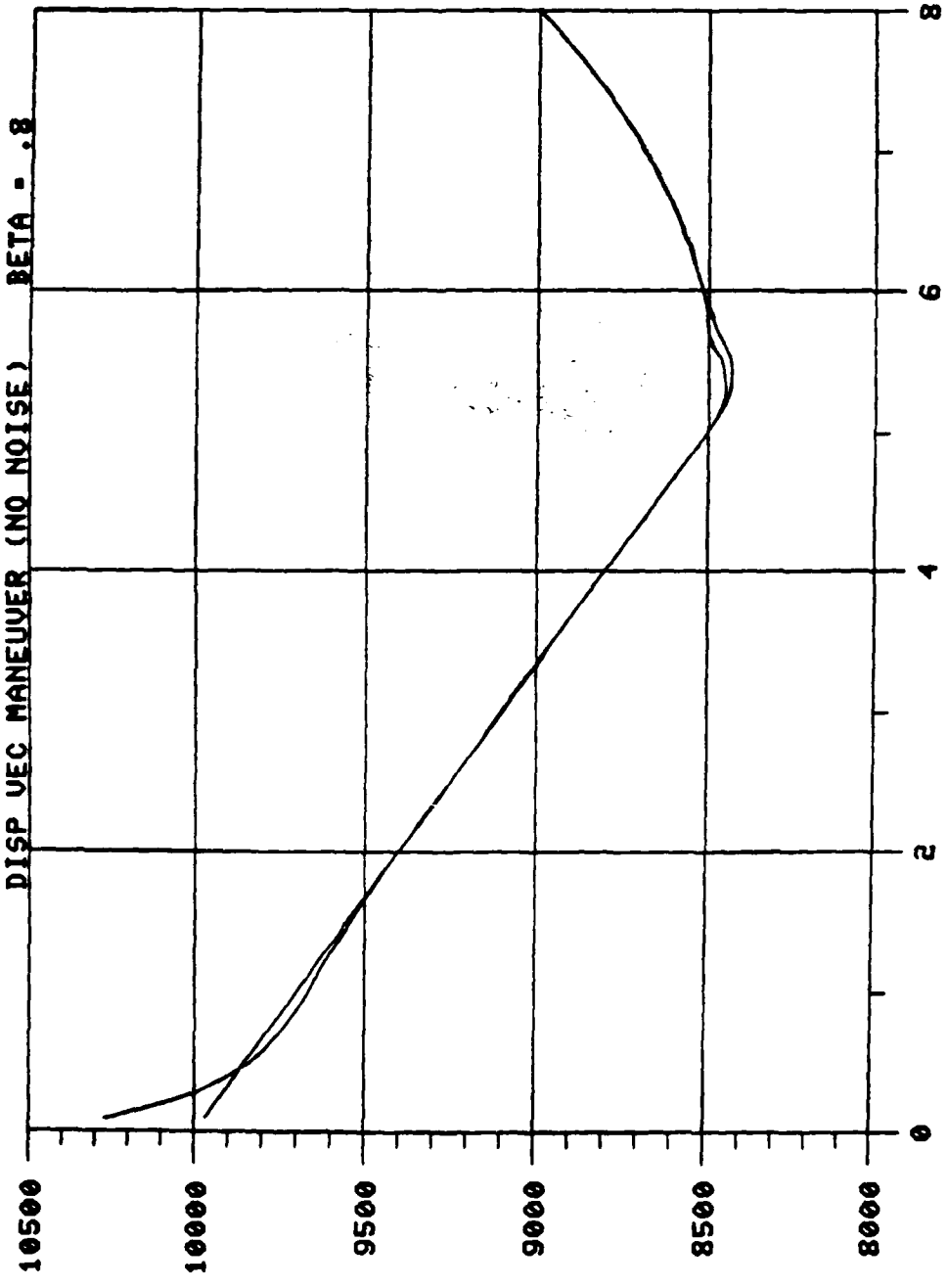

DISP VEC MANEUVER (NO NOISE) BETA = .8
10500
10000
9500
9000
8500
8000
0
2
4
6
8

Figure 6

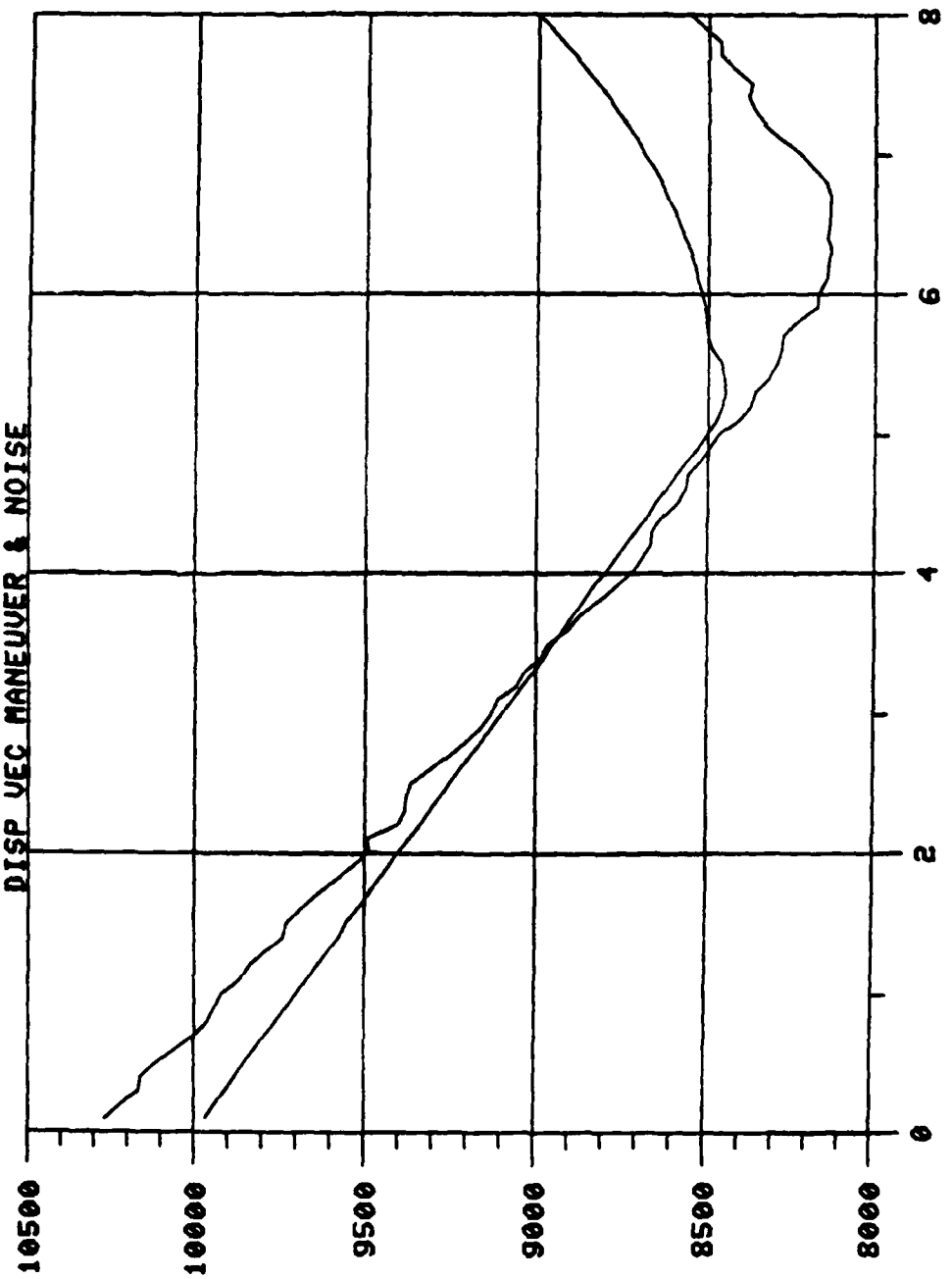

DISP VEC MANEUVER & NOISE
10500
10000
9500
9000
8500
8000
0
2
4
6
8

Figure 7

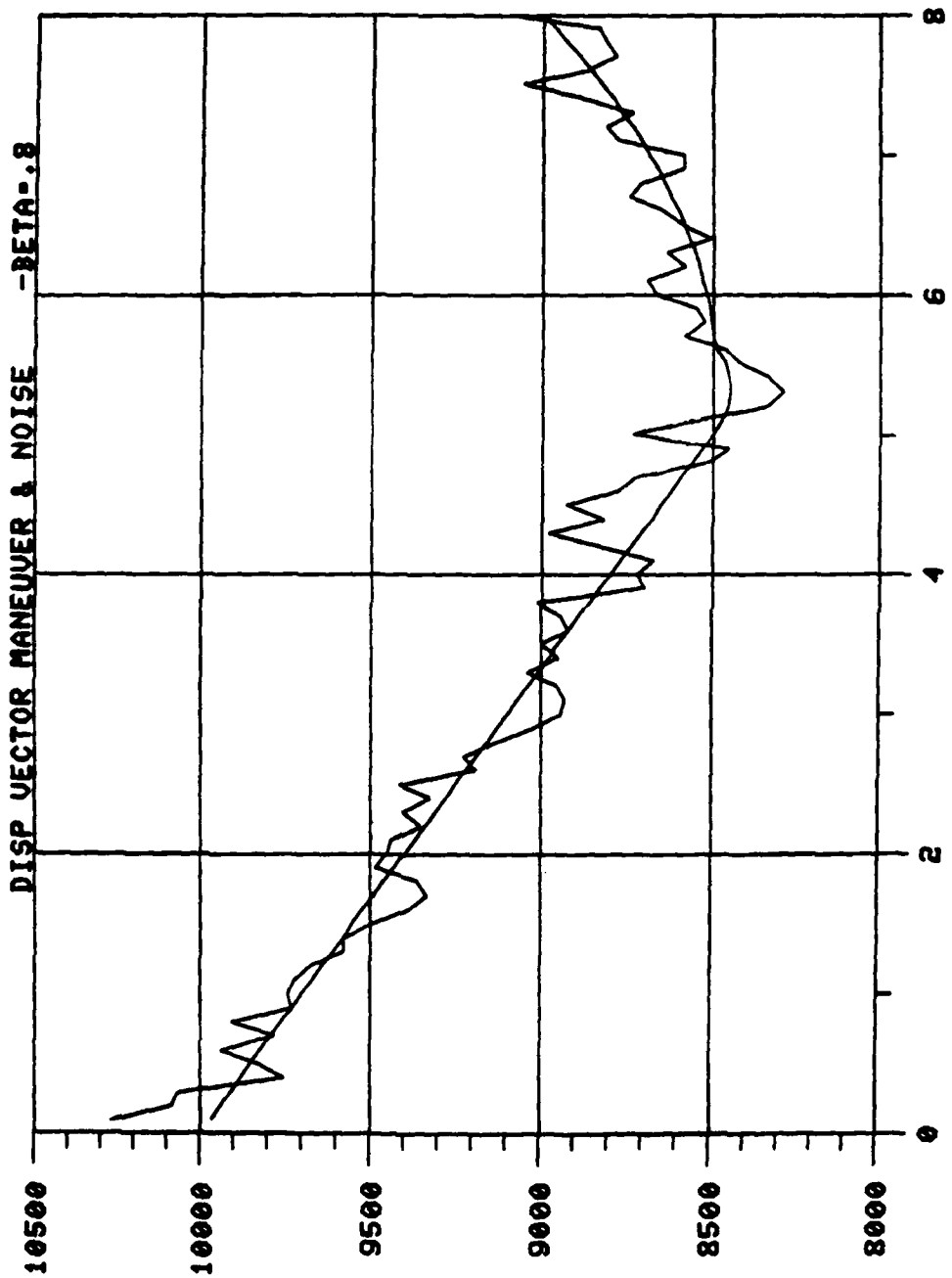

DISP VECTOR MANEUVER & NOISE -BETA=.8
10500
10000
9500
9000
8500
8000
0
2
4
6
8

Figure 8

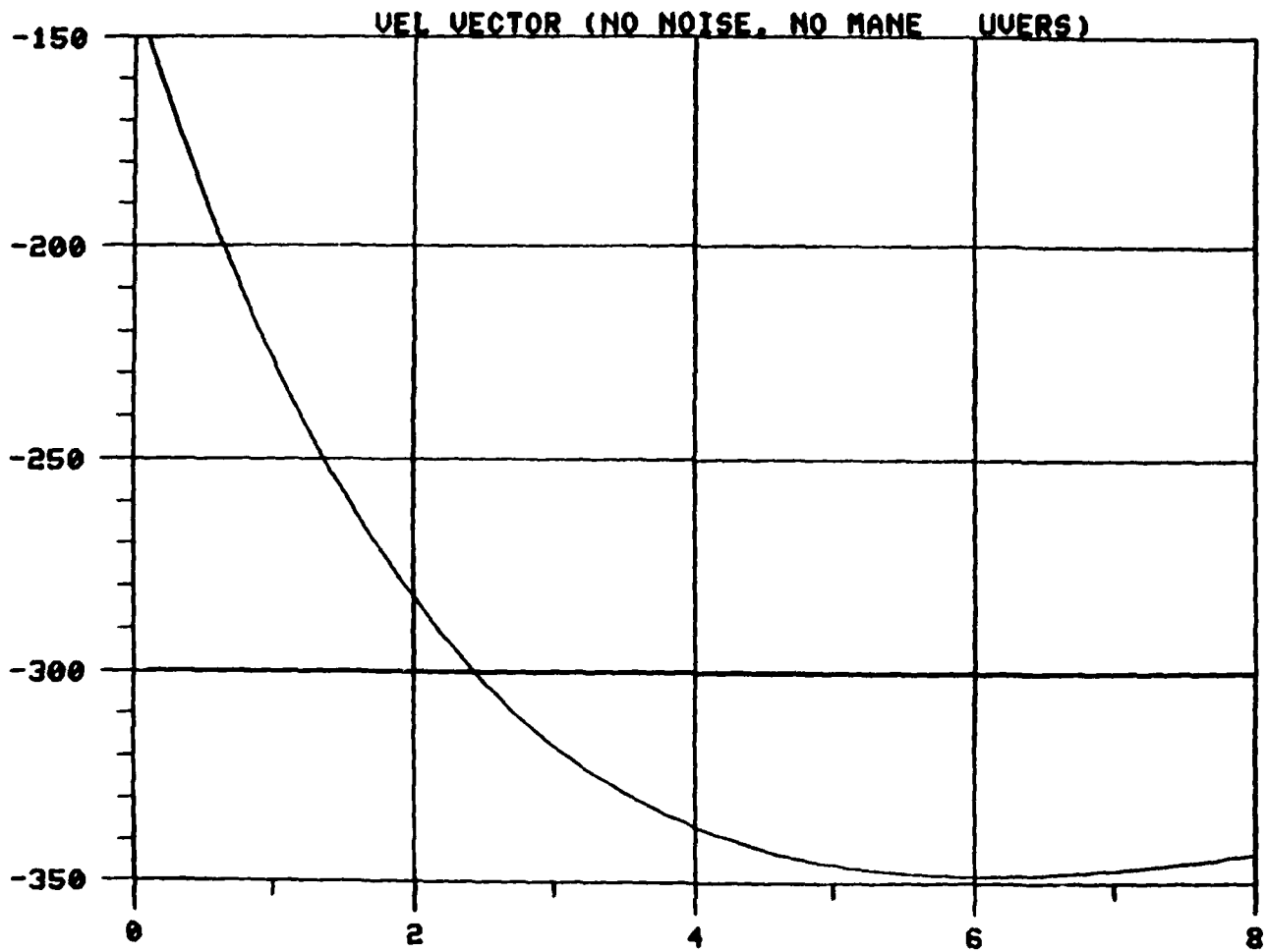


Figure 9

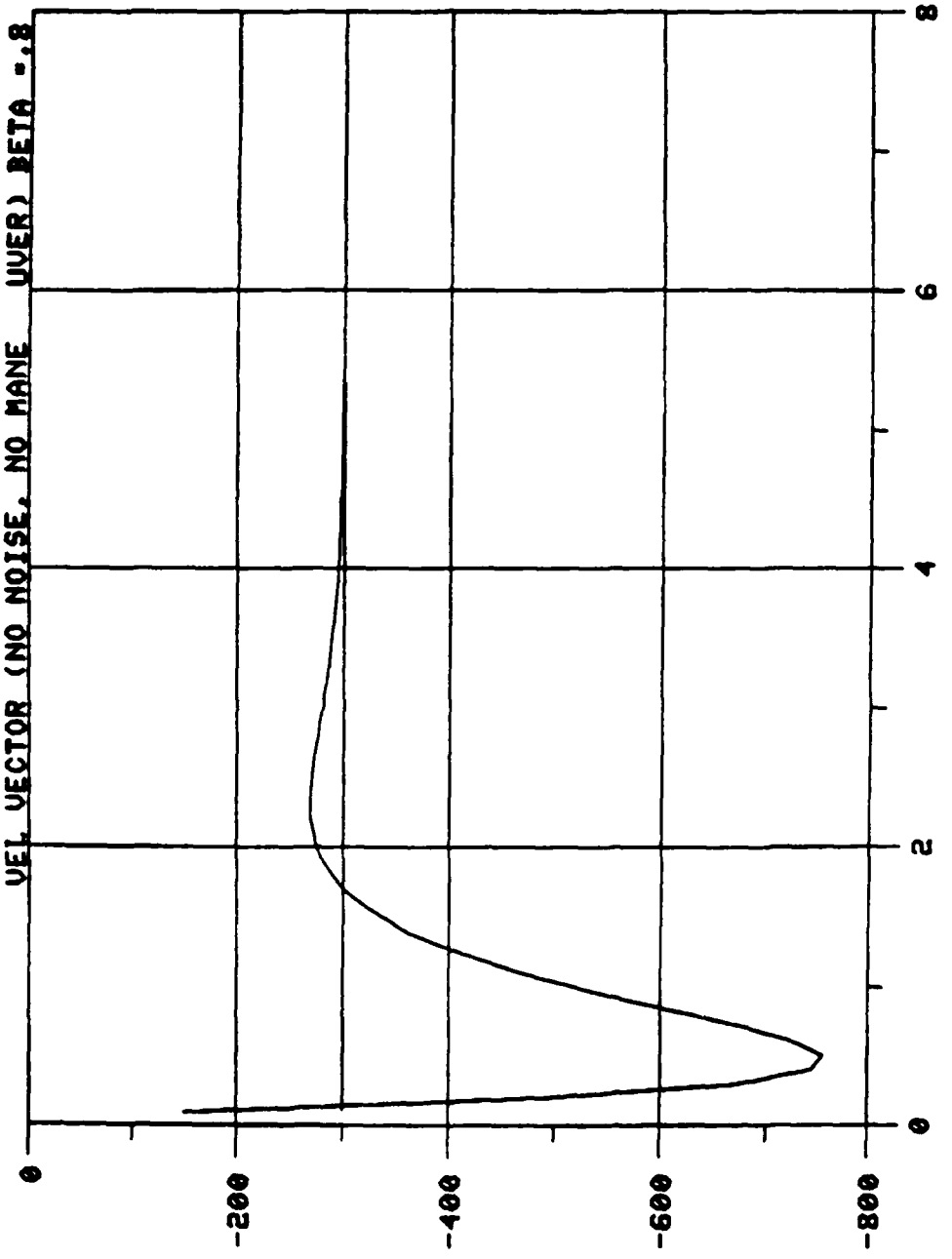


Figure 10

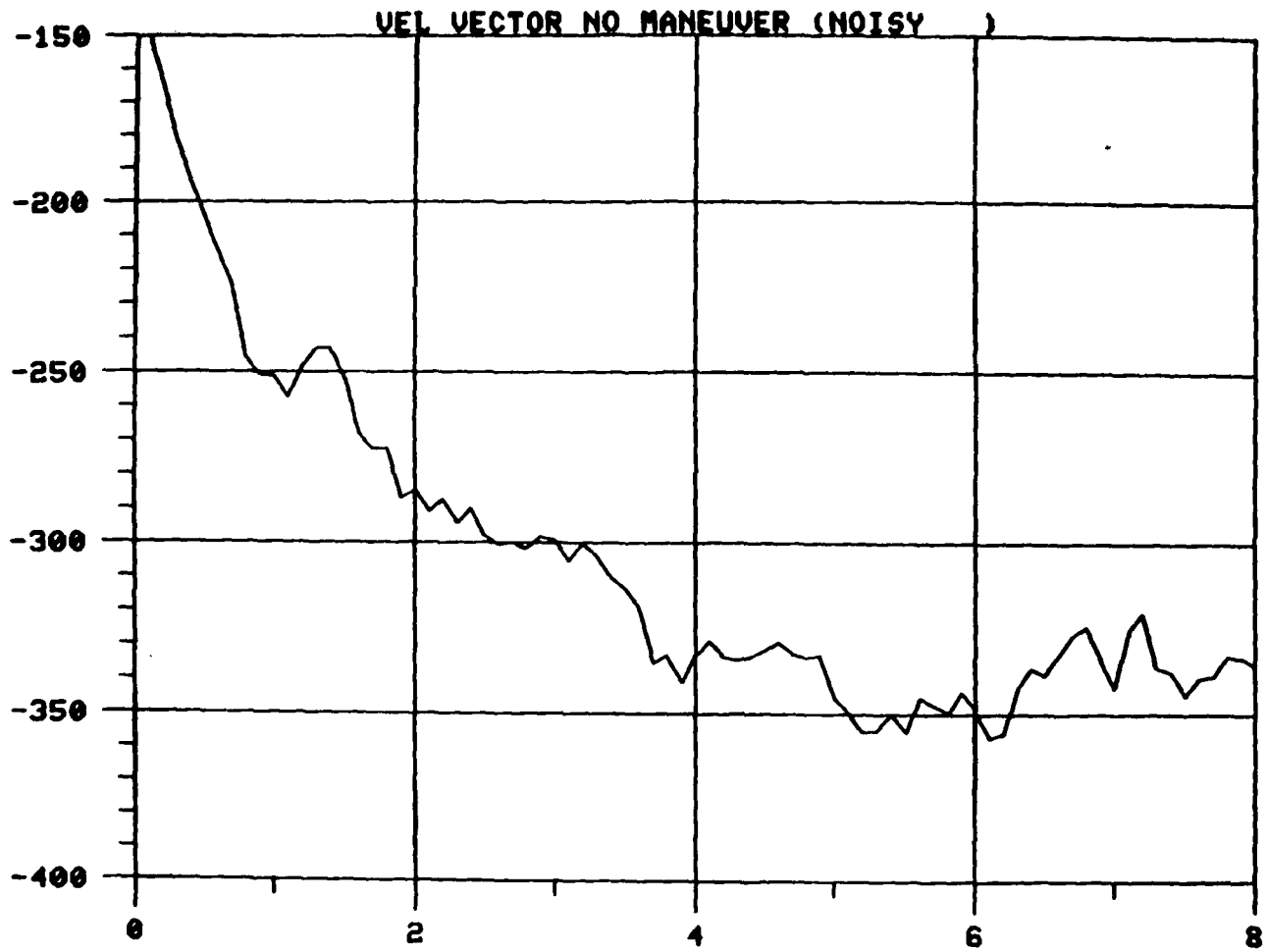


Figure 11

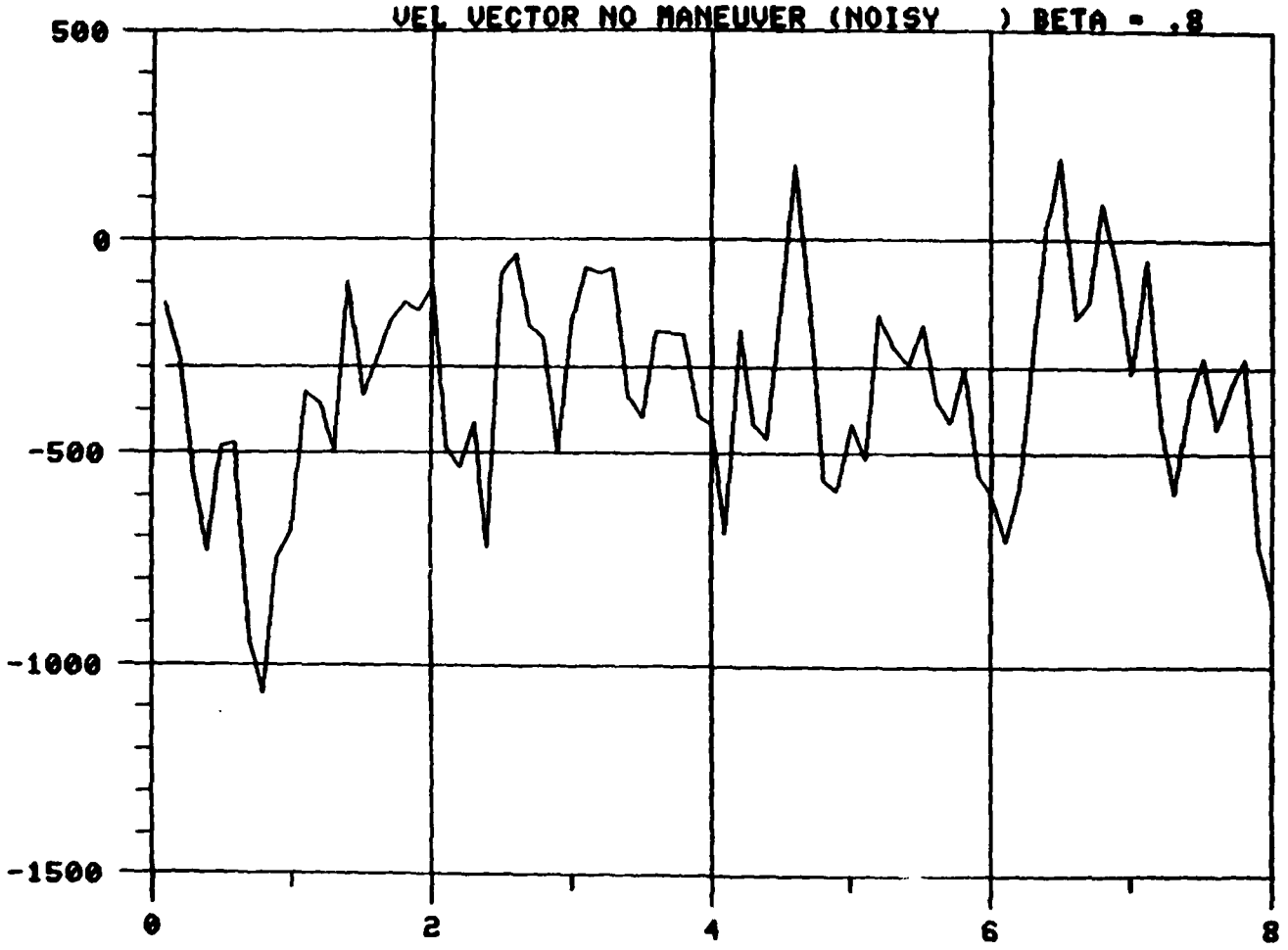


Figure 12

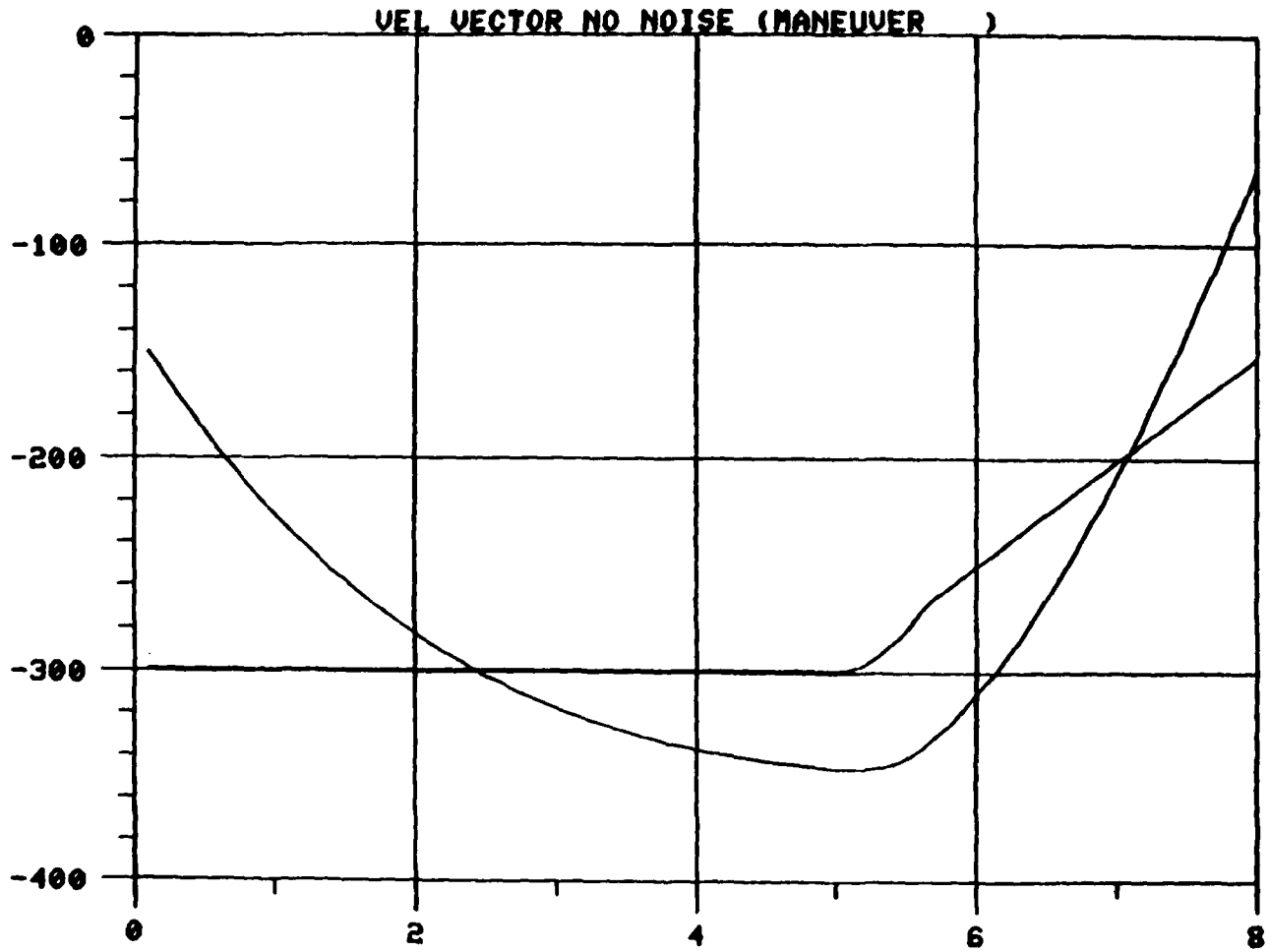


Figure 13

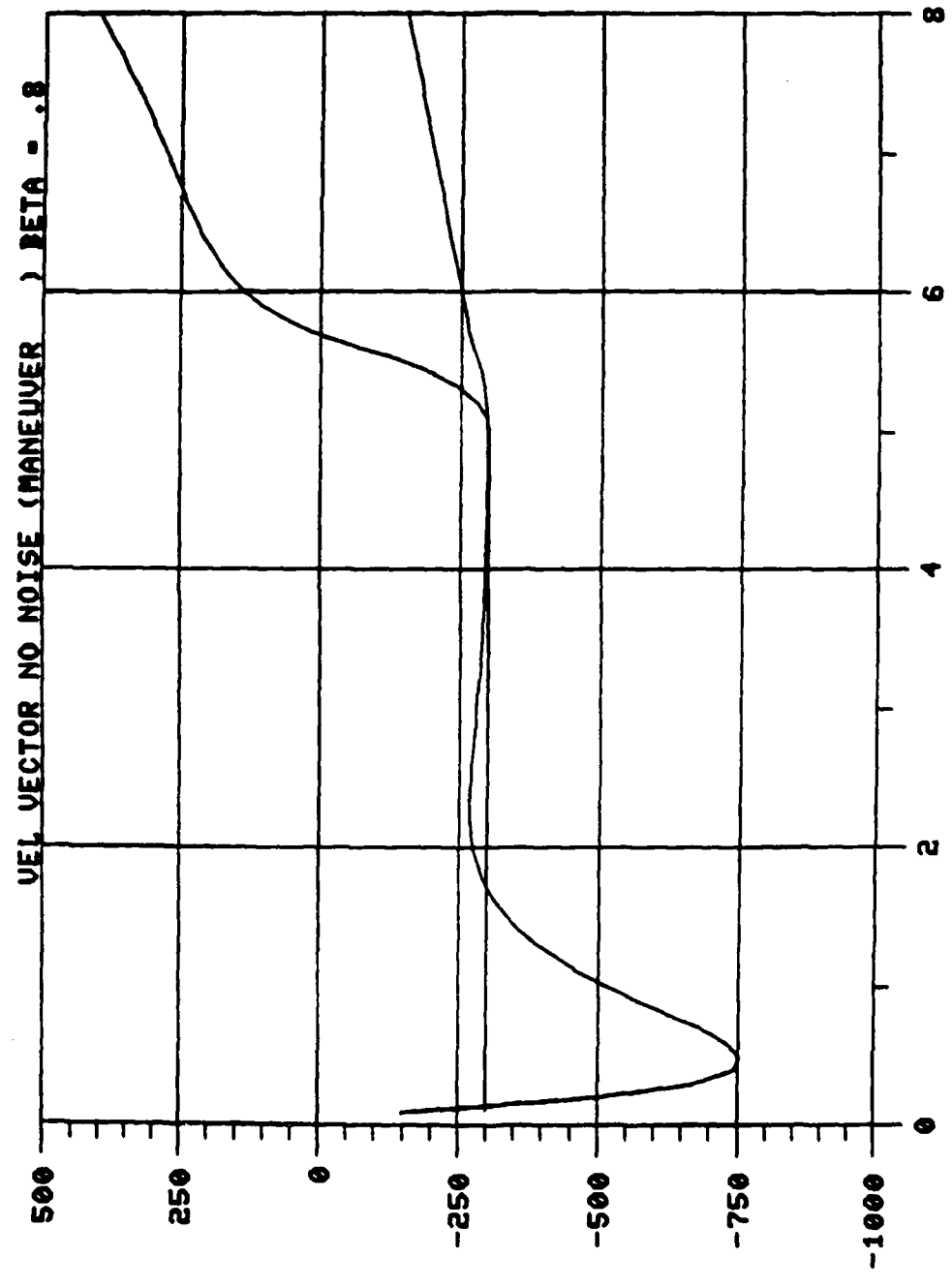

VEL VECTOR NO NOISE (MANEUVER) BETA = .8
500
250
0
-250
-500
-750
-1000
0
2
4
6
8

Figure 14

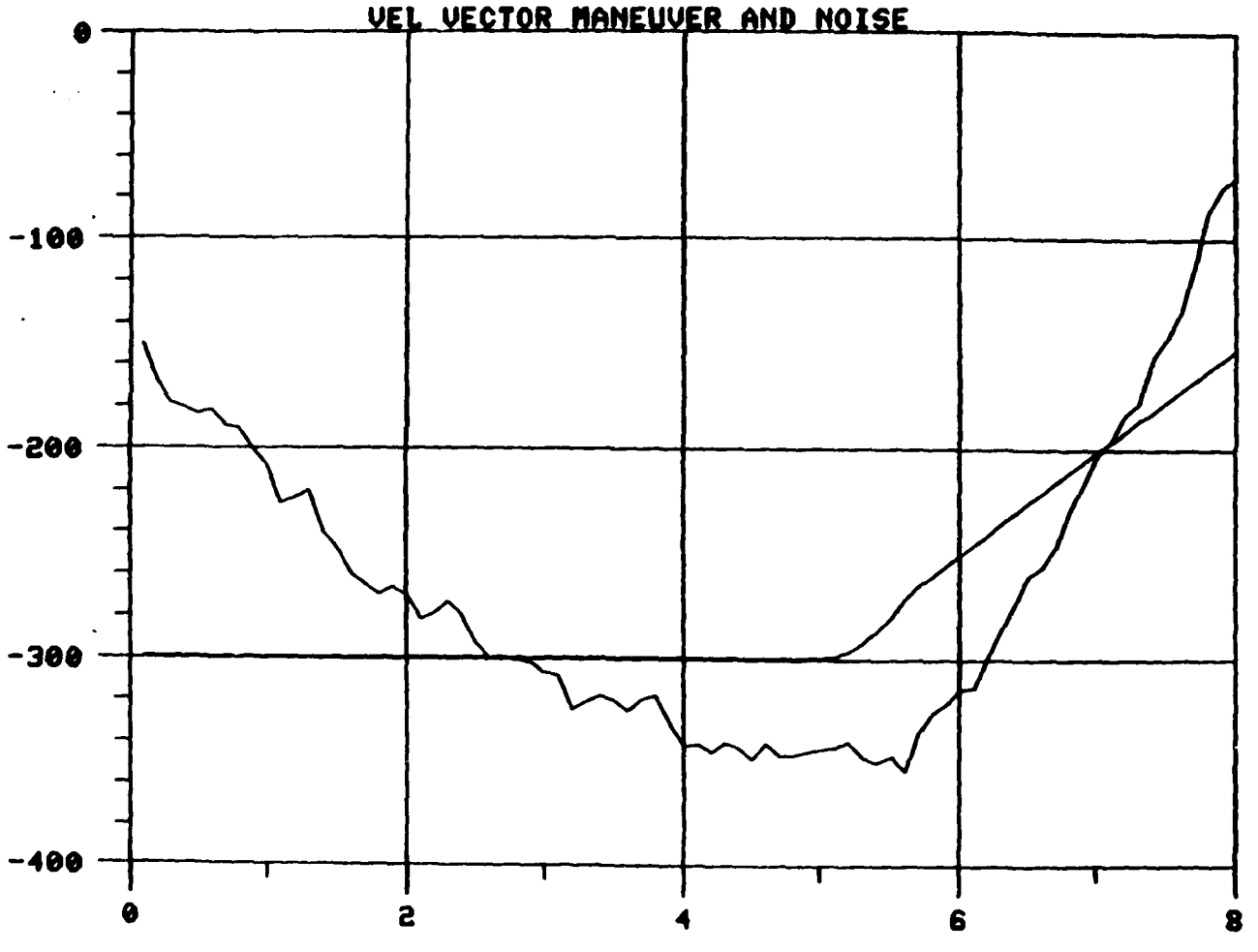


Figure 15

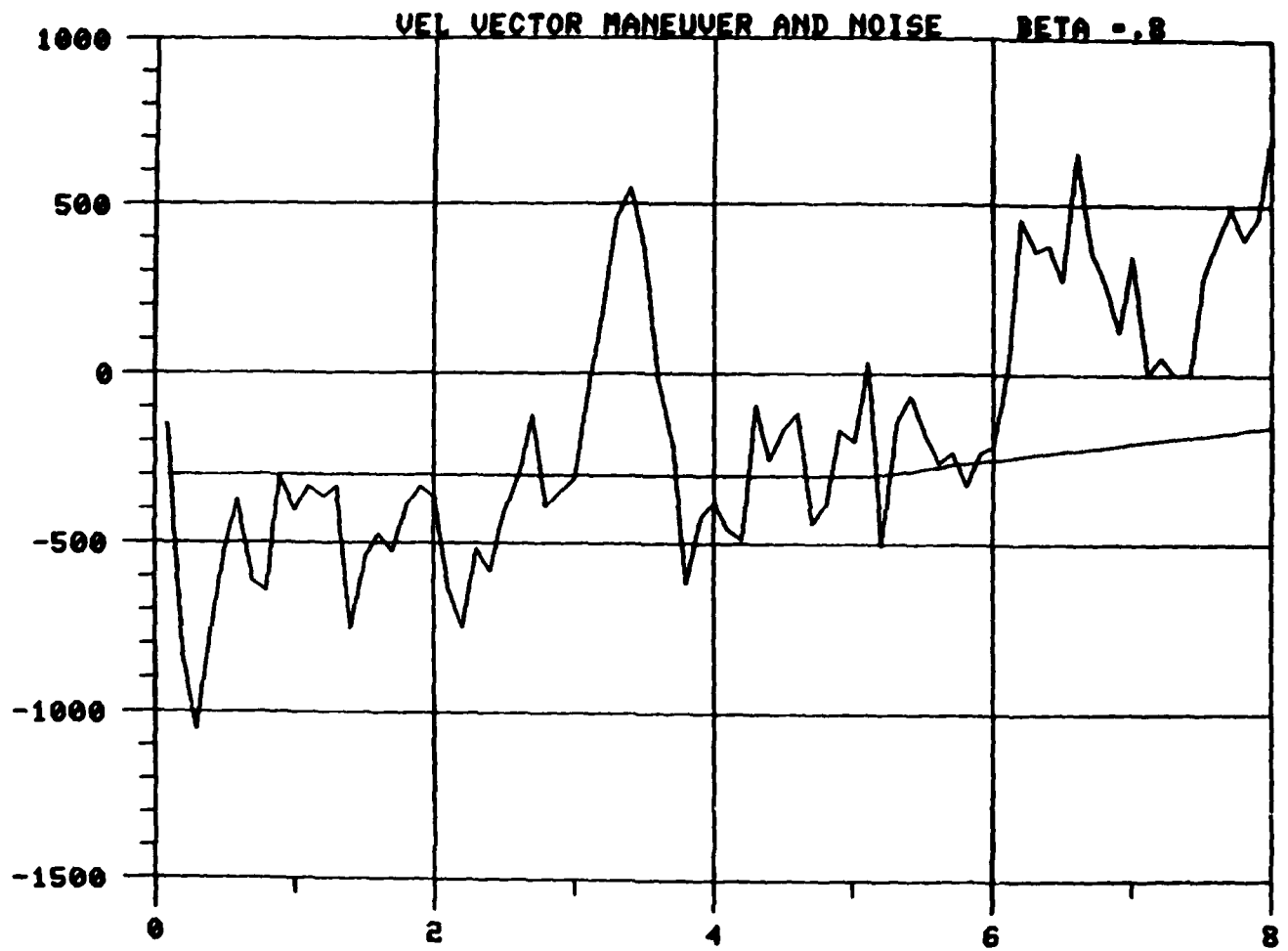

VEL VECTOR MANEUVER AND NOISE
BETA =.8
1000
500
0
-500
-1000
-1500
0
2
4
6
8

Figure 16

MAIN PROGRAM

```
C       THIS IS A GMK ESTIMATOR
        DIMENSION ZM(100), XBARM(100), ZOM(100), XDBARM(100)
        DIMENSION ZDDM(100),TT(100), XDLBM(100)
        CHARACTER *20 NAME
        REAL K,KV
        INTEGER C1
        R = (DELT**2)/2. →
5       W = 0.
        C1 = 0
        NO = 1
C
10      FORMAT('1',30X,'INPUT SECTION')
20      FORMAT(1X,'**********************************************
     1**********************************************')
C
C
        TYPE 30
30      FORMAT('1','****** ALL VALUES ENTERED ARE FLOATING POINT -- UNLES
     1S OTHERWISE INDICATED****'//)
35      TYPE 40
40      FORMAT(1X,'PLEASE ENTER NAME TO CALL THIS SET OF OUTPUT'/)
        READ(5,50) NAME
50      FORMAT(A20)
        PRINT 60, NAME
60      FORMAT(1HX,'NAME OF OUTPUT IS ',A20)
C
C
70      TYPE 80
80      FORMAT(1X,'SEED MUST BE AN ODD INTEGER '//,
     1  ' PLEASE ENTER SEED NUMBER FOR SUBROUTINE'/)
        READ(5,90,ERR = 70) NO
90      FORMAT (I5)
        PRINT 100, NO
100     FORMAT (2X,'SEED NUMBER IS  ',I5/)
110     FORMAT (9X,' SEED FOR THIS RUN IS ',I5//)
C CHECK TO SEE IF SEED IS WITHIN SPECIFIED BOUNDS
           IF(NO .LE. 0  .OR. NO  .GT. 32768) THEN
           PRINT *,'ERROR------ SEED MUST BE BETWEEN 1 AND 32768'
           GO TO 70
        ELSE
           CONTINUE
        ENDIF
C  CHECK TO SEE IF SEED IS ODD
        NH1 = NO/2
        HH1 = NO/2.
        IF(FNH1 .EQ. HH1) THEN
           PRINT *,'---ERROR---'
           GO TO 70
        ELSE
           CONTINUE
        ENDIF
        WRITE(6,100)
        WRITE(6,200)
        WRITE (6,60) NAME
        WRITE(6,110)  NO
C
C
        IF (MR.EQ.1) GO TO 175
        TYPE 120
120     FORMAT(1X,' XBAR=ESTIMATE OF POSITION'/,1X,' XDBAR = TIME DERIVATI
     1VE ESTIMATE'/,1X,' XDDBAR=ESTIMATE OF ACCELERATION'/)
```

```
C
130     TYPE 140
140     FORMAT(1X,'PLEASE ENTER XBAR,XDBAR, AND XDDBAR')
        C1 = 0
        READ(5,150,ERR=130) XBAR, XDBAR, XDDBAR
150     FORMAT(F8.2,2(E12.5))
160     FORMAT(1X,' XBAR= ',F8.2,' XDBAR= ',E12.5,' XDDBAR= ',E12.5/)
170     FORMAT(14X,' XBAR= ',F8.2,' XDBAR= ',E12.5,' XDDBAR= ',
     1  E12.5/)
175     TYPE 160, XBAR, XDBAR, XDDBAR
180     TYPE 190
190     FORMAT(1X,'ENTER 1 TO CHANGE VALUES JUST ENTERED')
        ACCEPT 200,  C1
200     FORMAT(I1)
        IF(C1 .EQ. 1) GO TO 130
        WRITE (6,170) XBAR, XDBAR, XDDBAR
C
C       HOLD  VALUES
        XBV = XBAR
        XDBV = XDBAR
        XDDBV = XDDBAR
C
        IF (NR .EQ. 1) THEN
            PRINT 210, G, H, K
            PRINT 215, B
215     FORMAT(2X,'BETA IS ',E16.7/)
210     FORMAT(16X,'G= ',E14.7,' H= ',E14.7,' K= ',E14.7/)
           PRINT *, 'ENTER 1 TO CHANGE BETA'
           ACCEPT 200, C1
           IF(C1 .EQ. 1) CALL GHK(G, H, K, B)
           CONTINUE
        ELSE
             CALL GHK (G, H, K, B)
             WRITE (6,210) G, H, K
        ENDIF
C       HOLD VALUE OF BETA G, H, AND K
        GV = G
        HV = H
        KV = K
        BV = B
C
        IF (NR .EQ. 1) GO TO 255
220     TYPE 230
        C1 = 0
230     FORMAT(1X,'ENTER GAUSIAN NOISE SIGMA AND NOISE MEAN')
        READ (5,240,ERR=220) SIG, RMEAN
240     FORMAT(1X,'NOISE FACTOR IS ',F6.2,' MEAN IS ',F6.2/)
250     FORMAT(16X,'NOISE FACTOR IS ',F6.2,' MEAN IS ',F6.2/)
255     PRINT  240, SIG, RMEAN
260     FORMAT(2F6.2)
        TYPE 190
        ACCEPT 200, C1
        IF(C1 .EQ. 1) GO TO 220
        WRITE (6,250) SIG, RMEAN
C
        SIGV = SIG
        RMNV = RMEAN
C
        IF(NR .EQ. 1) GO TO 325
        TYPE 270
270     FORMAT(1X,'Z1=INITIAL TRUE POSITION'/1X,'ZD1=TIME DERIVATIVE',/
```

```
     1  1X,'ZDD=ACCELERATION'/)
280       C1 = 1
290       TYPE 300
300       FORMAT(1X,'PLEASE ENTER Z1, ZD1, AND ZDD')
          READ(5,150,ERR=290) Z1, ZD1, ZDD
310       FORMAT(1X,' Z1=',E12.5,' ZD1= ',E12.5,' ZDD= ',E12.5/)
320       FORMAT(15X,' Z1=',E12.5,' ZD1= ',E12.5,' ZDD= ',E12.5/)
325       PRINT 310, Z1, ZD1, ZDD
          TYPE 190
          ACCEPT 200, C1
          IF(C1 .EQ. 1) GO TO 280
          WRITE ( 6,320) Z1, ZD1, ZDD
C
          Z1V = Z1
          ZD1V = ZD1
          ZDDV = ZDD
C
          IF(NR .EQ. 1) GO TO 415
          TYPE 330
330       FORMAT(1X,'T = TIME',/1X,'DELT = TIME INCREMENT',/1X,'TM = TIME OF
     1MANEUVER'//)
C
C
          TYPE 340
340       FORMAT(1X,'IMAX=NUMBER OF COMPUTATIONAL STEPS'/)
350       TYPE 360
          C1 = 1
360       FORMAT(1X,'PLEASE ENTER T, DELT, TM, AND  IMAX (INTEGER)')
          READ(5,370,ERR=350) T, DELT, TM, IMAX
370       FORMAT(3F6.2,I3)
380       FORMAT(1X,'IMAX= ',I3/)
390       FORMAT(16X,'IMAX= ',I3/)
400       FORMAT(1X,' T= ',F6.2,' DELT= ',F6.2,' TM=  ',F6.2/)
410       FORMAT(15X,' T= ',F6.2,' DELT= ',F6.2,' TM=  ',F6.2/)
415       PRINT 380, IMAX
          PRINT  400, T, DELT, TM
          TYPE 190
          ACCEPT 200,C1
          IF(C1 .EQ. 1) GO TO 350
          WRITE (6,390) IMAX
          WRITE (6,410) T, DELT, TM
          WRITE(6,20)
C HOLD VALUES OF T, DELT, TM, AND IMAX
          TV = T
          TMV = TM
          DELV = DELT
          IMAXV = IMAX
C
          WRITE(6,420)
420        FORMAT('1')
C
C ***************   COMPUTATION SECTION ******************
430       TYPE 435
          C1 = 0
435       FORMAT (1X,' ENTER 1 TO PRINT RESULTS FOR EACH STEP ')
          READ(5,200,ERR=430) C1
C
          CALL GAUSS (NO,SIG,PMEAN,WG)

          DO 14V I=1,IMAX
          T = T + DELT
```

```
C
C        STORE VALUES TO BE PRINTED IN AN ARRAY
C
         ZH(I)     = Z
         XBARH(I)  = XBAR
         ZDH(I)    = ZD
         XDBARH(I)= XDBAR
         ZDDH(I)   = ZDD
         XDDHH(I)  = XDDBAR
         TT(I) = T
C
440      CONTINUE
C
C     *********  PRINT VALUES STORED IN ARRAY  ***********
         WRITE(6, 590)
580      FORMAT('1','STEP',4X,'Z',12X,'XBAR',12X,'ZD',12X,'XDBAR',
     1   4X,'ZDD',10X,'XDDBAR'//)
C
         DO 590 JP = 1,IMAX
         WRITE(6, 600) JP, ZH(JP), XBARH(JP), ZDH(JP), XDBARH(JP),
     1   ZDDH(JP), XDDHH(JP)
600      FORMAT(1X,I3,6(1X,E12.5)//)
590      CONTINUE
C
C  CHECK TO SEE WHETHER PLOTS ARE WANTED
         C1=' '
         PRINT *,' ENTER 1 TO PLOT DATA'
         ACCEPT 200, C1
         IF(C1 .EQ. 1) THEN
C        CALL PLOT PROGRAM
C  CHECK TO SEE WHETHER TO PLOT DISPLACEMENT OR VELOCITY VECTORS
603            TYPE 605
605            FORMAT  (' ENTER 1 TO PLOT DISPLACEMENT VECTORS'/
     1' ENTER 2 TO PLOT VELOCITY VECTORS'/,
     1' ENTER 3 TO PLOT ACCELERATION VECTORS'/)
               C1 = 4
               ACCEPT 200, C1
         IF(C1 .NE. 1 .AND.  C1 .NE. 2 .AND. C1 .NE. 3) THEN
               PRINT *, 'PLEASE ENTER 1 OR 2 OR 3'
               GO TO 603
         ELSE
                 CONTINUE
         ENDIF
              IF(C1 .EQ. 1)   CALL PLOT (T1,XBARH,ZH,IMAX,'A')
              IF(C1 .EQ. 2)   CALL PLOT (TT,XBARH,ZDH,IMAX,'A')
              IF(C1 .EQ. 3)   CALL PLOT (TT,ZDDH,XDDHH,IMAX,'A')
C    END OF PLOT SUBROUTINE
         ELSE
              CONTINUE
         ENDIF
C
         PRINT 610, 'A'
         WRITE(6,610) 'A'
610      FORMAT(1X,'END OF JOB FOR PROGRAM ',A1)
C
C        CHECK FOR ANOTHER RUN
         TYPE 620
         NN = 2
620      FORMAT (' ENTER 1 TO MAKE ANOTHER RUN, ')
         ACCEPT 200, NN
         IF (NN .EQ. 1) THEN
```

```
            IF (NP .EQ. 1) THEN
C  REINITIALIZE NAMES TO ORIGINAL VALUES
                  XBAR = XBV
                  XDBAR = XDBV
                  XDDBAR = XDDBV
                  SIG = SIGV
                  RMEAN = RMNV
                  Z1 = Z1V
                  ZD1 = ZD1V
                  ZDD = ZDDV
                  B = BV
                  G = GV
                  H = HV
                  K = KV
                  T = TV
                  TM = TMV
                  DELT = DELV
                  IMAX = IMAXV
                  GO TO 5
            ELSE
                  CONTINUE
            ENDIF
C
             STOP
             END
```

REFERENCES

1. "Bistatic Tracking and Trajectory, Estimating Techniques," Henry C. Holman, Dissertation, Southeastern Institute of Technology, 1981.

2. "VAX 11/780" User's Guide.

APPENDIX A

OPERATING PROCEDURES

1. Procedure for running program:

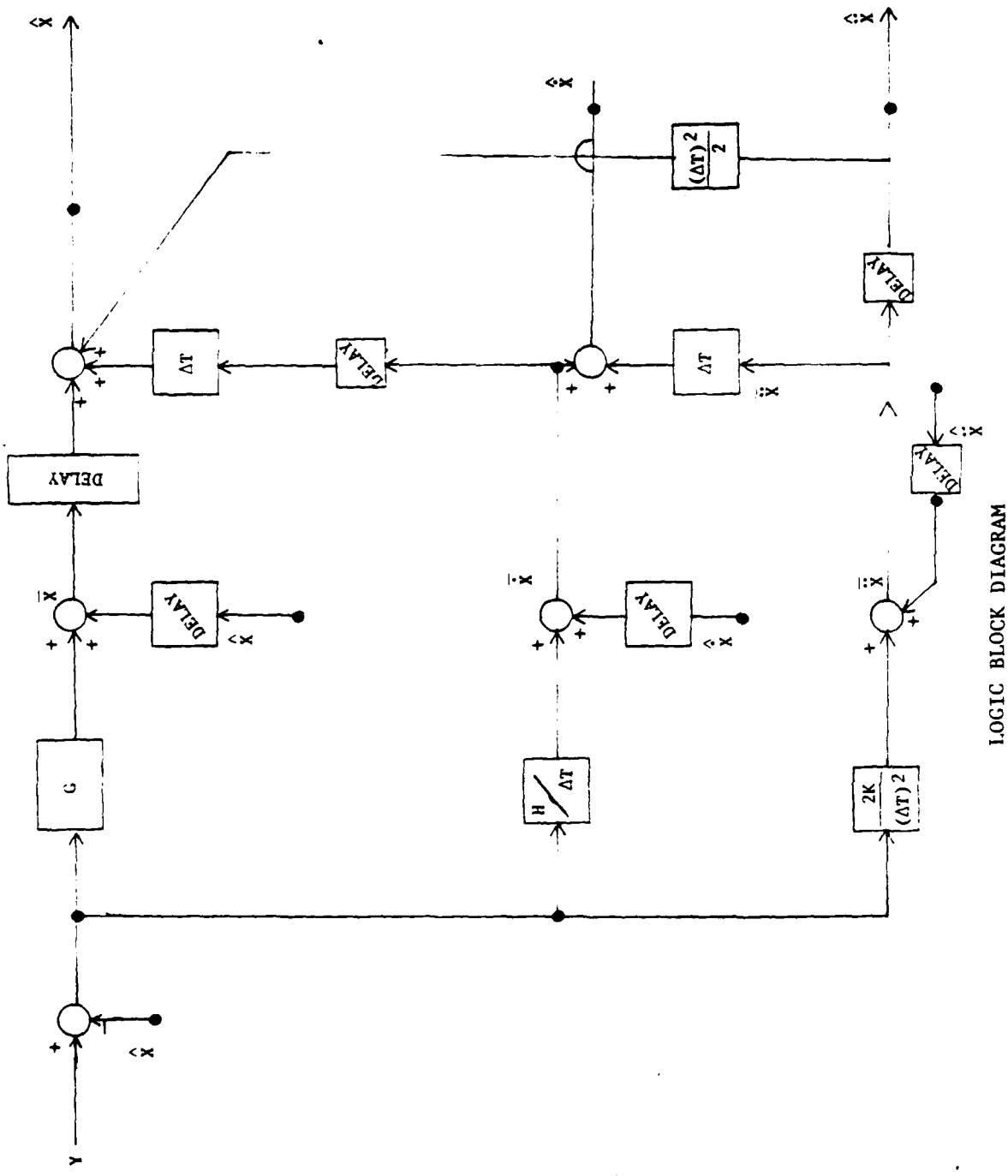
   a. LOG ON TO VAX 780
   b. TYPE "ASSIGN EST.OUT FOR 006"
   c. TYPE "ASSIGN EST.TEX FOR001"
   d. TYPE "RUN EST"
   e. FOLLOW PROMPTS

2. Procedure for obtaining hardcopies:

   a. TYPE "PR EST.OUT"
   b. OBTAIN HARDCOPY FROM OPERATOR
   c. LOGIN ON TEKTRONIX NUMBER
   d. TYPE "EST TEX"
   e. PROGRAM SUPPORT CONTACT - SANDRA BRAZELTON/876-2295

APPENDIX B

LOGIC BLOCK DIAGRAM



LOGIC BLOCK DIAGRAM

APPENDIX C

SOURCE LISTING

```
C       MAIN PROGRAM
C       THIS IS A GMK ESTIMATOR
        DIMENSION ZH(100), XBARH(100), ZDH(100), XDBARH(100)
        DIMENSION ZDDH(100),ET(100), XDDBH(100)
        CHARACTER *80 NAME
        REAL K,KV
        INTEGER C1
5       A = 0.
        C1 = C
        NO = 1
C
10      FORMAT('1',30X,'INPUT SECTION')
20      FORMAT(1X,'**********************************************
     1**********************************************')
C
C
        TYPE 30
30      FORMAT('1','****** ALL VALUES ENTERED ARE FLOATING POINT --UNLES
     1S OTHERWISE INDICATED****'//)
35      TYPE 40
40      FORMAT(1X,'PLEASE ENTER NAME TO CALL THIS SET OF OUTPUT'/)
        READ(5,50) NAME
50      FORMAT(A80)
        PRINT 60, NAME
60      FORMAT(10X,'NAME OF OUTPUT IS ',A80)
C
C
70      TYPE 80
80      FORMAT(1X,'SEED MUST BE AN ODD INTEGER '///,
     1  ' PLEASE ENTER SEED NUMBER FOR SUBROUTINE'/)
        READ(5,90,ERR = 70) NO
90      FORMAT (I5)
        PRINT 100, NO
100     FORMAT (2X,'SEED NUMBER IS  ',I5/)
110     FORMAT (9X,' SEED FOR THIS RUN IS ',I5//)
C CHECK TO SEE IF SEED IS WITHIN SPECIFIED BOUNDS
           IF(NO .LE. 0  .OR. NO  .GT. 32768) THEN
           PRINT *,'ERROR------ SEED MUST BE BETWEEN 0 AND 32768'
           GO TO 70
        ELSE
           CONTINUE
        ENDIF
C  CHECK TO SEE IF SEED IS ODD
        NH1 = NO/2
        AN1 = NO/2.
        IF(NH1 .EQ. AN1) THEN
           PRINT *,'---ERROR---'
           GO TO 70
        ELSE
           CONTINUE
        ENDIF
        WRITE(6,10)
        WRITE(6,20)
        WRITE (6,60) NAME
        WRITE(6,110)  NO
C
C
        IF (NP.EQ.1) GO TO 175
        TYPE 120
120     FORMAT(1X,' XBAR=ESTIMATE OF POSITION'/,1X,' XDBAR = TIME DERIVA'
     1VE ESTIMATE'/,1X,' XDDBAR=ESTIMATE OF ACCELERATION'/)
```

```
C
130     TYPE 140
140     FORMAT(1X,'PLEASE ENTER XBAR,XDBAR, AND XDDBAR')
        C1 = C
        READ(5,150,ERR=130) XBAR, XDBAR, XDDBAR
150     FORMAT(F8.2,2(E12.5))
160     FORMAT(1X,' XBAR= ',F8.2,' XDBAR= ',E12.5,' XDDBAR= ',E12.5/)
170     FORMAT(14X,' XBAR= ',F8.2,' XDBAR= ',E12.5,' XDDBAR= ',
     1  E12.5/)
175     TYPE 160, XBAR, XDBAR, XDDBAR
180     TYPE 190
190     FORMAT(1X,'ENTER 1 TO CHANGE VALUES JUST ENTERED')
        ACCEPT 200,  C1
200     FORMAT(I1)
        IF(C1 .EQ. 1) GO TO 130
        WRITE (6,170) XBAR, XDBAR, XDDBAR
C
C       HOLD  VALUES
        XBV = XBAR
        XDBV = XDBAR
        XDDBV = XDDBAR
C
        IF (NR .EQ. 1) THEN
            PRINT 210, G, H, K
            PRINT 215, B
215     FORMAT(2X,'BETA IS ',E16.9/)
210     FORMAT(10X,'G= ',E14.7,' H= ',E14.7,' K= ',E14.7/)
           PRINT *, 'ENTER 1 TO CHANGE BETA'
           ACCEPT 200, C1
           IF(C1 .EQ. 1) CALL GHK(G, H, K, B)
           CONTINUE
        ELSE
             CALL GHK (G, H, K, B)
             WRITE (6,210) G, H, K
        ENDIF
C        HOLD VALUE OF BETA G, H, AND K
         GV = G
         HV = H
         KV = K
         BV = B
C
         IF (NR .EQ. 1) GO TO 255
220      TYPE 230
         C1 = C
230      FORMAT(1X,'ENTER GAUSIAN NOISE SIGMA AND NOISE MEAN')
         READ (5,240,ERR=220) SIG, RMEAN
240      FORMAT(1X,'NOISE FACTOR IS ',F6.2,' MEAN IS ',F6.2/)
250      FORMAT(10X,'NOISE FACTOR IS ',F6.2,' MEAN IS ',F6.2/)
255      PRINT  240, SIG, RMEAN
260      FORMAT(2F6.2)
         TYPE 190
         ACCEPT 200, C1
         IF(C1 .EQ. 1) GO TO 220
         WRITE (6,250) SIG, RMEAN
C
         SIGV = SIG
         RMNV = RMEAN
C
         IF(NR .EQ. 1) GO TO 325
         TYPE 270
270      FORMAT(1X,'Z1=INITIAL TRUE POSITION'/1X,'ZD1=TIME DERIVATIVE',/
```

```
     1   1X,'ZDD=ACCELERATION'/)
280      C1 = 0
290      TYPE 300
300      FORMAT(1X,'PLEASE ENTER Z1, ZD1, AND ZDD')
         READ(5,130,ERR=290) Z1, ZD1, ZDD
310      FORMAT(1X,' Z1=',E12.5,' ZD1= ',E12.5,' ZDD= ',E12.5/)
320      FORMAT(15X,' Z1=',E12.5,' ZD1= ',E12.5,' ZDD= ',E12.5/)
325      PRINT 310, Z1, ZD1, ZDD
         TYPE 190
         ACCEPT 200, C1
         IF(C1 .EQ. 1) GO TO 230
         WRITE ( 6,320) Z1, ZD1, ZDD
C
         Z1V = Z1
         ZD1V = ZD1
         ZDDV = ZDD
C
         IF(NR .EQ. 1) GO TO 415
         TYPE 330
330      FORMAT(1X,'T = TIME',/1X,'DELT = TIME INCREMENT',/1X,'TM = TIME O
     1MANEUVER'//)
C
C
         TYPE 340
340      FORMAT(1X,'IMAX=NUMBER OF COMPUTATIONAL STEPS'/)
350      TYPE 360
         C1 = 0
360      FORMAT(1X,'PLEASE ENTER T, DELT, TM, AND  IMAX (INTEGER)')
         READ(5,370,ERR=350) T, DELT, TM, IMAX
370      FORMAT(3F6.2,I2)
380      FORMAT(1X,'IMAX= ',I3/)
390      FORMAT(10X,'IMAX= ',I3/)
400      FORMAT(1X,' T= ',F6.2,' DELT= ',F6.2,' TM=  ',F6.2/)
410      FORMAT(15X,' T= ',F6.2,' DELT= ',F6.2,' TM=  ',F6.2/)
415      PRINT 380, IMAX
         PRINT  400, T, DELT, TM
         TYPE 190
         ACCEPT 200,C1
         IF(C1 .EQ. 1) GO TO 350
         WRITE (6,390) IMAX
         WRITE (6,410) T, DELT, TM
         WRITE(6,20)
C HOLD VALUES OF T, DELT, TM, AND IMAX
         TV = T
         TMV = TM
         DELV = DELT
         IMAXV = IMAX
C
         WRITE(6,420)
420       FORMAT('1')
C
C ***************   COMPUTATION SECTION ******************
430      TYPE 435
         C1 = 0
435      FORMAT (1X,' ENTER 1 TO PRINT RESULTS FOR EACH STEP ')
         READ(5,200,ERR=430) C1
C

         DO 440 I=1,IMAX
         T = T + DELT
         IF (T .LT. TM) GO TO 450
```

```
        ZDD = 79.5 * (T-TM)
        IF (ZDD .GE. 49.1) ZDD = 49.1
450     ZD = ZD1 + ZDD * (T-TM)
        Z  = Z1 + ZD*T
        IF(T .GE. TM) Z = Z + 0.5 * ZDD * (T-TM)**2

C
        CALL GAUSS (NC,SIG,PMEAN,WG)
        Y  = Z + WG
C
C
        IF (I .EQ. 1 ) GO TO 460
C********** ESTIMATE AT CURRENT TIME *************
C*************************************************************
C     NEXT THREE STATEMENTS ARE SKIPPED ON FIRST PASS         *
C*************************************************************
        XBAR   = XHAT   + G * (Y-XHAT)
        XDBAR  = XDHAT  + (H/DELT) * (Y-XHAT)
        XDDBAR = XDDHAT + (( 2 * K)/(DELT**2)) * (Y-XHAT)
C*************************************************************
C      THIS IS THE LOGIC FOR THE FIRST PASS                   *
C*************************************************************
C
        P = (DELT**2)/2.
460     XHAT  = XBAR  + XDBAR  * DELT + XDDBAR * P
        XDHAT = XDBAR + XDDBAR * DELT
        XDDHAT= XDDBAR
C

C****************** PRINT  ROUTINE ********************
C
C  **** CHECK TO SEE IF ALL RESULTS ARE TO BE PRINTED ***
C
        IF (C1 .EQ. 0) GO TO 470
C
C  **** SKIP THIS SECTION IF C1 = 0 ********
C
        WRITE (6, 430)I
430     FORMAT(10X,'RESULTS FOR STEP ',I3//)
        WRITE (6, 490)
490     FORMAT(3X,'T',13X,' XBAR ',9X,' XDBAR ',5X,' XDDBAR')
        WRITE (6, 500)T, XBAR, XDBAR, XDDBAR
500     FORMAT(1X,E10.5,1X,E12.5,2X,E12.5,1X,E12.5//)
        WRITE(6, 510)
510     FORMAT(3X,' XHAT ',9X,' XDHAT ',3X,' XDDHAT')
        WRITE(6, 500) XHAT, XDHAT, XDDHAT
520     FORMAT(3X,3(E12.5,3X)//)
        WRITE(6, 530)
530     FORMAT(5X,'Z ',15X,'ZD',14X,'ZDD')
        WRITE(6, 540) Z, ZD, ZDD
540     FORMAT(4X,E12.5,4X,E12.5,4X,E12.5//)
        WRITE(6, 550)
550     FORMAT(3X,'XBAR - Z ',9X,'XDBAR-ZD',7X,'XDDBAR-ZDD')
        WRITE(6,560)(XBAR-Z),(XDBAR-ZD),(XDDBAR - ZDD)
560     FORMAT(3X,3(E12.5,3X)//)
        WRITE(6,570) Y, (Y-XHAT)
570     FORMAT(1X,'Y= ',E12.5,3X,'(Y-XHAT) = ',E12.5//)
C
C ******** END OF SECTION TO BE SKIPPED ******
C
C
```

```
470     CONTINUE!C1 = 0 DO ONLY PRINT VALUES STORED IN ARRAY
C
C       STORE VALUES TO BE PRINTED IN AN ARRAY
C
        ZH(I)     = Z
        XDARH(I) = XDAR
        ZDH(I)    = ZD
        XDDARH(I)= XDDAR
        ZDDH(I)   = ZDD
        XDDDH(I) = XDDDAR
        TT(I) = T
C
440     CONTINUE
C
C     ********* PRINT VALUES STORED IN ARRAY ***********
        WRITE(6, 580)
580     FORMAT('1','STEP',4X,'Z',10X,'XDAR',10X,'ZD',10X,'XDDAR',
     1  2X,'ZDD',10X,'XDDDAR'//)
C
        DO 590 JP = 1,IMAX
        WRITE(6, 600) JP, ZH(JP), XDARH(JP), ZDH(JP), XDDARH(JP),
     1  ZDDH(JP), XDDDH(JP)
600     FORMAT(1X,I3,5(1X,E12.5)//)
590     CONTINUE
C
C  CHECK TO SEE WHETHER PLOTS ARE WANTED
        C1=0
        PRINT *,' ENTER 1 TO PLOT DATA'
        ACCEPT 200, C1
        IF(C1 .EQ. 1) THEN
C       CALL PLOT PROGRAM
C  CHECK TO SEE WHETHER TO PLOT DISPLACEMENT OR VELOCITY VECTORS
603             TYPE 605
605             FORMAT  (' ENTER 1 TO PLOT DISPLACEMENT VECTOR'/
     1' ENTER 2 TO PLOT VELOCITY VECTOR'/,
     1' ENTER 3 TO PLOT ACCELERATION VECTOR'/)
                C1 = 0
                ACCEPT 200, C1
        IF(C1 .NE. 1 .AND.  C1 .NE. 2 .AND. C1 .NE. 3) THEN
                PRINT *, 'PLEASE ENTER 1 OR 2 OR 3'
                GO TO 603
         ELSE
                CONTINUE
         ENDIF
              IF(C1 .EQ. 1)   CALL PEST (TT,XDARH,ZH,IMAX,NAME)
              IF(C1 .EQ. 2)   CALL PEST (TT,XDARH,ZDH,IMAX,NAME)
              IF(C1 .EQ. 3)   CALL PEST (TT,ZDDH,XDDDH,IMAX,NAME)
C   END OF PLOT ROUTINE
         ELSE
              CONTINUE
         ENDIF
C
         PRINT 610, NAME
         WRITE(6,610) NAME
610      FORMAT(1X,'END OF JOB FOR PROGRAM ',A30)
C
C        CHECK FOR ANOTHER RUN
         TYPE 620
         NR = 0
620      FORMAT (' ENTER 1 TO MAKE ANOTHER RUN ')
         ACCEPT 200, NR
```

```
      IF (NP .EQ. 1) THEN
C REINITIALIZE NAMES TO ORIGINAL VALUES
            X9AR = X2V
            XD9AR = XDEV
            XDDBAR = XDDBV
            SIG = SIGV
            RMEAN = RMNV
            Z1 = Z1V
            ZD1 = ZD1V
            ZDD = ZDDV
            B = BV
            G = GV
            H = HV
            K = KV
            T = TV
            TM = TMV
            DELT = DELV
            IMAX = IMAXV
            GO TO 5
      ELSE
            CONTINUE
      ENDIF
C
       STOP
       END
```

SUBROUTINE PEST

```
      SUBROUTINE PEST (TT,XD1,XD2,IMAX,NAME)
C THIS SUBROUTINE PLOTS  TIME VERSES TRUE POSITION
      CHARACTER *80 NAME
      CALL INITT(120)
      CALL BINITT
      CALL NPTS (IMAX)
      CALL CHECK (TT,XD1)
      CALL DSPLAY (TT,XD1)
      CALL CPLOT (TT,XD2)
      CALL LABLIT (80,NAME,312,704,1)
      CALL FINITT (0,700)
      RETURN
      END
```

SUBROUTINE BETA

```
      SUBROUTINE BETA (B)
C     THIS PROGRAM CALCULATES BETA
      REAL LAM
10    PRINT *, ( ' PLEASE ENTER TIME CONSTANT ')
      READ ( 5,50,ERR = 10) TC
      LAM = - 1./TC
      PRINT 40, LAM
40    FORMAT(1X,'THE VALUE OF LAMBDA IS ',F5.2)
50    PRINT *, (' PLEASE ENTER DELT ')
      READ (5,60,ERR = 50) DELT
60    FORMAT ( F5.2)
      PRINT 80 , DELT
80    FORMAT(1X,'THE VALUE OF DELT IS ' F5.2)
      E = 2.71828182
      X = LAM * DELT
      PRINT 90, X
90    FORMAT(1X,'LAMBDA *DELT = ',E16.9)
      B = E ** X
      RETURN
      END
```

SUBROUTINE GAUSS

```
C       SUBROUTINE GAUSS
C
C       PURPOSE
C          COMPUTES A NORMALLY DISTRIBUTED RANDOM NUMBER WITH A GIVE
C          MEAN AND STANDARD DEVIATION
C
C       USAGE
C          CALL GAUSS(IX,S,AM,V)
C
C       DESCRIPTION OF PARAMETERS
C          IX -IX MUST CONTAIN AN ODD INTEGER NUMBER
C              LESS THAN 32768 ON THE FIRST ENTRY TO GAUSS. THEREAFTE
C              IT WILL CONTAIN A UNIFORMLY DISTRIBUTED INTEGER RANDO
C              NUMBER GENERATED BY THE SUBROUTINE FOR USE ON THE NEX
C              ENTRY TO THE SUBROUTINE.
C          S  -THE DESIRED STANDARD DEVIATION OF THE NORMAL
C              DISTRIBUTION.
C          AM -THE DESIRED MEAN OF THE NORMAL DISTRIBUTION
C          V  -THE VALUE OF THE COMPUTED NORMAL RANDOM VARIABLE
C
C       REMARKS
C          THIS SUBROUTINE USES RANDU WHICH IS MACHINE SPECIFIC
C
C       SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
C          RANDU
C
C       METHOD
C          USES 12 UNIFORM RANDOM NUMBERS TO COMPUTE NORMAL RANDOM
C          NUMBERS BY CENTRAL LIMIT THEOREM. THE RESULT IS THEN
C          ADJUSTED TO MATCH THE GIVEN MEAN AND STANDARD DEVIATION.
C          THE UNIFORM RANDOM NUMBERS COMPUTED WITHIN THE SUBROUTINE
C          ARE FOUND BY THE POWER RESIDUE METHOD.
C
C     .....................................................................
C
      SUBROUTINE GAUSS(IX,S,AM,V)
      A=0.0
      DO 50 I=1,12
      CALL RANDU(IX,IY,Y)
      IX=IY
   50 A=A+Y
      V=(A-6.0)*S+AM
      RETURN
      END
```

SUBROUTINE GHK

```
C    THIS SUBROUTINE COMPUTES THE VALUE OF G, H, AND K FROM BETA
C
      SUBROUTINE GHK (G, H, K,Y)
      REAL K, KV
      INTEGER C1
C
C     THIS BLOCK DETERMINES IF BETA WILL BE ENTERED FROM THE KEYBOARD
C     OR COMPUTED VIA  A CALL TO SUBROUTINE BETA.
C
20       PRINT *, ' ENTER 1 IF YOU WANT TO ENTER THE VALUE OF BETA FR
     1 THE KEYBOARD'
         NB = 0
         C1 = 0
         READ (5,40,ERR = 20) NB
40       FORMAT (I1)
             IF ( NB .NE. 1) THEN
                  CALL BETA (B)
             ELSE
60                PRINT *,' PLEASE ENTER THE VALUE OF BETA'
                  READ (5,80,ERR = 60) B
80       FORMAT (E16.9)
         ENDIF
C
C
C     COMPUTE THE VALUE OF G, H, AND K. RETURN VALUE IN Y
C
         Y = B
         G = 1. - Y **3
         H = 3./2. * ( ( 1. - Y**2) * (1.-Y) )
         K = 1./2. * ( (1.-Y)**3)
90       PRINT 100, Y
100      FORMAT (15X,' THE VALUE OF BETA IS ',E16.9/)
         WRITE (6,100) Y
105      PRINT 110, G, H, K
110      FORMAT (' G IS ',E12.5,/' H IS ',E12.5,/
     1 ' K IS ',E12.5//)
         PRINT *, ' ENTER 1 TO CHANGE VALUE OF BETA'
         ACCEPT 140, C1
         IF (C1 .EQ. 1) GO TO 20
140      FORMAT (I1)
         RETURN
         END
```

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