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UNIVERSITY OF SOUTHAMPTON

DEPARTMENT OF SHIP SCIENCE

FACULTY OF ENGINEERING AND APPLIED SCIENCE

MANUAL FOR THE CALCULATION OF VERTICAL MOTIONS OF A SHIP USING AN APPLE MICROCOMPUTER

by P.A. Wilson

Ship Science Report No. 1/83

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Manual for the calculation of vertical motions of a ship, using an Apple Microcomputer

Introduction

With the increase in computer power, both in terms of memory and speed, that has become available in the last seven or so years, the need to use large mainframe computers for long repetitive calculations has become less necessary. Programs have been available references (1,2) for the calculation of five degrees of freedom motions of a ship at speed in any given seaway, at the University for some years. The results from these programs have been validated for the vertical mode of motion both experimentally at model and full scale. With this in mind and also knowing the complexity of the vertical motion program module the task of converting the module to work on a microcomputer was undertaken.

The choice of microcomputer was narrow since if the program execution time was to be quick, it had to be written in a language that was capable of being compiled. Since the program was already written in FORTRAN and the department possesses a number of Apple 48K microcomputers which have been modified to use FORTRAN, the choice had been made virtually by default. The modifications to the Apple microcomputer are the addition of a Microsoft Z80 card together with the CP/M operating system and Fortran assembler and compiler as supplied by Microsoft.

With this Apple system it is possible to break down the heave and pitch module into a number of smaller program modules that will each fit into the machine. The programs are now selected from a menu that requires the user to select which module is required. The menu program is run simply by typing MENU followed by carriage return.

There are six program modules at present. Each module has a defined role and has had all its results validated.

Input/Modify Section Data (GENSHIP)

As the program title suggests it is used to generate the data file that is used for input to other programs. The

program leads the user through the input data via questions and answers. Also this program allows the user to modify a previously defined data file.

One point that is always worth bearing in mind is that the programs are written in FORTRAN. This program language differentiates between numbers called integers and real numbers. The former are used where the integer variable is required to be exactly represented by the computer memory, whereas the latter are represented by a binary approximation within the machine. The outcome of this is that when typing in data that is a real variable a decimal point is always required to be input. An example of this is displacement e.g. 1000.0. Each piece of input data is given the type of variable that it represents in the paragraph that follows.

Most data is self explanatory.

Input

1) Title. This is a set of eight characters that are used to specify files created on the data disk. The characters may be letters, numbers or spaces, the only condition is that the first character must be a letter.

1a) Has this ship already been defined?
If the answer is YES and you want to modify any data then read the section at the end of this program module.

2) Number of ship stations (Integer) either 11 or 21 are to be used. Station 1 is the aft perpendicular,11 or 21 is the fore perpendicular.

3) Units. It is possible to use either metric or imperial measure in the subsequent input data. The units are,

Metric	Tonnes, metres, seconds
Imperial	Tons, feet seconds

4) Displacement (real). Is the displaced mass of the ship in the specified units, e.g. tonnes.

5) Calculation type (integer). This allows choice of either the ship motions and/or the bending moments and shear

forces in a seaway.

If you have only the total mass of the ship and the longitudinal radius of gyration then it is only possible to calculate the motion of the ship. If you have a weight distribution of the ship, it is possible to choose to calculate the motions only or motion, bending moments and shearing forces.

If only the total weight displacement of the ship is known together with the longitudinal centre of gravity and the longitudinal radius of gyration of the ship, these are termed as the summary mass distribution; then it is only possible to calculate the heave and pitch of whole ship.

If the weight distribution is known and input, then it is possible to calculate the heave and pitch, as well as the dynamic bending moment and vertical shear force on the ship.

6) Ship length (real) is the waterline length.

7) For each of the stations three or four pieces of data are input all are real.

a) Full section beam
b) Sectional area coefficient defined as sectional area divided by full beam and draft.
c) Draft of section to the waterline.

If bending moments and shearing forces are required then

d) Section weight.

If the section weights have been input skip inputs 8,9.

8) Radius of gyration (real) in length units.

9) Longitudinal centre of gravity relative to midships (real), positive values are measured forwards.

No more input is required for the summary mass case.

Input 10,11,12

When the bending moment and shearing force option has been

specified the program automatically calculates these values at midships. It is possible to obtain values of the bending moments and shearing forces at any of the other ship stations.

10) Initial station number (integer).

11) Final station number (integer).

12) Increment between the values in 10,11 above (integer).

If 10,11 are identical then input 12 should have a value of 1.

Heave is non-dimensionalised with respect to wave height.
Pitch is non-dimensionalised with respect to wave slope.
Bending moment is non-dimensionalised with respect to density, length squared and beam at midships.
Shearing force is non-dimensionalised with respect to density, length and midship beam.

The program generates one output file with the name of ship title together with the three character addition DAT. The program checks that the data that has been input balances. This means it checks that the displacement as calculated by the sectional area coefficients beam and draughts matches the input displacement to within 2%. It checks that the LCB and LCG are within 0.5% of the ship length. It checks that the weight distribution matches the input displacement, to within 2%.

If any of these conditions is violated the program stops with message 'STOP IN PRELMB ERROR NUMBER' N.

N= 1 means volume displacement error
2 weight displacement
3 LCB/LCG error.

It automatically returns now to the menu program.

Channels used within the program are as follows

1) Screen
7) Output file XXXXXXXX.DAT
where XXXXXXXX is the ship title.

Modification of Data Files

If a modification to data that has already been input is required, then it is possible to modify any piece of data in the following manner.

The process of modification is for the program to read from the named data file a piece of information, e.g. the ship length. This value is then displayed and a question is posed as to whether this value is to be modified or not. If a modification is required then the new value is typed into the computer, which will replace the previous value.

The program also checks to see if previously calculated two dimensional properties are still applicable or not. If, say, the displacement has been changed then a message is displayed on the VDU saying that the TDP program needs re-running with the new data file.

When all the data has been checked over, the data is written onto the data file, replacing the previous data.

Added Mass and Damping Values (SHORTO)

The program reads data from the file generated in GENSHIP and creates another file which contains the TDPs.

The only input information that is required for this program is the title of the ship previously used in GENSHIP, i.e. the eight characters used to describe the ship, including any spaces.

The program calculates the two dimensional properties using a Lewis transformation of each section. A set of 25 non-dimensional frequencies are used for each of the sections, which are fixed within the machine.

Since each section data takes the order of 150 seconds to complete a message is printed as to the current state of the calculation.

Channels Used

1 Screen
7 Input from file XXXXXXXX.DAT
8 Output to file XXXXXXXX.TDP

The program generates an output file containing certain switches for other calculations, number of sections, section beam, draft and area coefficient, and if used the section weight. The array of non-dimensional frequencies at which the TDP's have been calculated, and finally for each section at each frequency the added mass and damping values.

Harmonic Response (SHORT 1)

This program solves the equations of motion for the frequencies/wavelength that are specified, at user specified speeds and headings.

Data is read from the file generated by SHORT0, a data file is generated with the ships response at the frequencies specified.

Input

1) Output of the results can be either to the screen or the printer.

2) Input the eight character filename.

3) Choice of output type.
Is it possible to have dimensional or non-dimensional output data for heave, pitch, bending moment and vertical shear.

4) If it is proposed to use short crested sea states in the statistical responses, it is necessary to 'spread' the spectra. If long crested seas, i.e. no spectral spreading then type 0.

If spread spectra are required, then a cosine type spreading function is used. The power of this spreading function is input. It must be an even power.[integer]

The next three questions refer to wavelength or wave frequency (radians per second).

It should be noted that if wave spectra are to be used the wave frequencies must be used.

5) Initial wavelength/frequency (real).

6) Final wavelength/frequency (real).

7) Incremental wavelength/frequency (real).

It should be noted that only 50 wavelengths or frequencies are allowable. If this value is exceeded the program is stopped with a message

STOP IN PRELIMC. ERROR NO. N

The value of N is 1 if more than 50 frequencies have been specified.

If the initial frequency/wavelength is greater than the final frequency/wavelength then N=3.

Also if the incremental value of frequency/wavelength is less than or equal to 0.0 N=3.

8) Number of Ship Speeds (Integer)
A maximum of 10 is allowable. If more than 10 is specified then the error message appears with N=0.

9) The ship speeds are input (real) one at a time, in knots, starting from the smallest and increasing to the largest. If the initial speed is greater than the final speed, then the error message appears with N=4.

10) The initial wave heading of the ship to the waves (real). Head seas are taken as 180°, following seas as 0°. There is no need to calculate for wave angles exceeding 180° as the motions are equivalent to that angle from 360°. The angle value is input in degrees.

11) The final wave heading angle in degrees (real).

Incremental value of heading angle from initial to final (real). Note that there is a maximum of 25 wave heading angles. If data values 8, 9 are identical then 10 is not needed.

Output

Output from the program consists of tables of the heave and pitch response of the ship at the specified speeds, headings and wavelengths/frequencies. The phase angles of the motions are also output.

Phase is defined as follows, being relative to the maximum waveslope at midships. Heave is measured positively downwards, pitch as positive bow-up and the wave position is positive upwards. Thus for very long waves the phase angle is 180.0°, for heave motion.

If the bending moment and shearing forces have been calculated the results are tabulated with the heave and pitch at midships.

If bending moments and shearing force are calculated at stations other than midships, these results are written to file for later printout. These results are stored on file XXXXXXXX.BMS.

To print out these results type XXXXXXXX.BMS and either the return key for the values to be printed on the screen or control P and then return to echo the screen results to the printer.

The program also generates a file containing the heave and pitch motions as well as the bending moment and shearing forces, if specified, for use in the statistics package. These are contained on a file named XXXXXXXX.RES. No phase angle results have been stored.

Channels Used

1	Screen
2	Printer
7	Input from XXXXXXXX.TDP
8	Output to XXXXXXXX.RES

9 Output to XXXXXXXX.BMS

Statistics (SHORT2)

This program calculates for specified spectra the variances and other statistical properties of the heave and pitch and the bending moment and shear force if specified. This program can only be used if waves have been specified in SHORT1.

If spread spectra have been specified in SHORT1 then the results are tabulated in this module.

Input

1) Hard copy output or not?
2) Ship file name as used in the previous programs.
3) Spectral type (integer).

Four types of spectra are available.

a) Newmann
b) Pierson-Moskowitz
c) Two Parameter I.T.T.C. or Bretschneider
d) J.O.N.S.W.A.P. as defined by the I.S.S.C.

4) Number of spectra (integer). A maximum of 10 is allowed.

5) a) For each spectrum the significant wave height (real)
   b) For either 3(C) or 3(D) the average wave period T.

It might be of use to know the following relationships between various wave periods

T_p the peak of the spectral density function
T_1 the average wave period, corresponding to the 'observed period'.
T_o the zero crossing period

$$T_1 = 1.08643T_o$$
$$T_p = 1.2957T_1$$
$$T_p = 1.40769T_o$$

Output

All speeds, headings and number of spectra the summary statistics are calculated. These being the mean square or variance, root mean square, average,1/3rd highest, and the 1/10th highest.

The results are always dimensional i.e. heave is in metres, pitch in degrees, bending moments in tonnes metres, vertical shear in tonnes.

If the spread response switch has been invoked then the spread responses as a function of heading are also calculated.

Channels Used

1 Screen
2 Printer
7 Output to file XXXXXXXX.OUT
8 Input from file XXXXXXXX.RES

Total Motion at a point (SHORT3)

It is possible to calculate the RMS values of absolute motion, velocity, and acceleration together with the relative motion, velocity and acceleration at a point in the ship.

To run this program the only input is

Input

1) Hard copy or not.
2) File name.
3) Numbers of total motion points (maximum of 21).
4) For each of (3) input the X distance of the point relative to the ship midships, positive measured forwards.
5) For each of (3) input the offset from the ship centreline, positive to starboard.

4) and 5) are repeated successively for each total motion point.

Output

The data points that have been input for each ship speed, wave angle and spectrum used in SHORT1 and SHORT2, the RMS value of absolute motion, velocity and acceleration at the point.

All results are dimensional, i.e. heave is in metres, pitch in degrees, shear in tonnes, bending moment in tonnes metre.

Subjective Motions (SHORT4)

This is contained on program disc 2.
This module calculates the subjective motion at up to 21 user specified points, or at the 1 or 21 input station values, for the combination of ship speeds, wave angles and sea spectra used in SHORT1 and SHORT2.

Input

1) Hard copy (Y/N)
2) Filename.
3) Either the input stations or particular points on the ship.

The following are only required if the user requires non standard position

4) Number of positions (Max of 21)
5) Distance of each of these 4) positions relative to midships, positive measured forwards.

Output

For each position of the ship, in each sea state wave heading and ship speed, the subjective motion (SM) is calculated.

Running the Program

Switch the Apple Microcomputer on, as well as the monitor and printer. This should cause a disc drive light to glow. Insert the ship motions program disc #1 and close the disc

drive door. After a few seconds the screen should display

A>

Type MENU to run the suite of programs. If option 6 on the menu is required then insert ship motions program disc #2 into drive 1. The data disc is always inserted into the disc drive 2. To start a new data disc, the disc has to be first of all formatted and then have some operating programs written upon it. This is done as follows. Insert the disc marked MASTER into drive 1 or A. Insert the disc to be formatted in drive B. Now type FORMAT B: The process takes about 25 seconds. When it is finished press return then type COPY B:=A:/S. This takes about 10 seconds. Now remove MASTER from drive A and then insert the ship motions program disc. Press Control C and this will cause the system to 'soft boot' i.e take notice of change of disc in drive A. Then proceed as the beginning of this section.

References

1. Users Manual of Program AEW2, Ship Science Report, No 2, 1976, P.A. Wilson.
2. Theory and computer program for calculation of the lateral motions of a ship, Ship Science Report No. 6/81 1981, P.A. Wilson.

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OLD VERSION

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Introduction

With the increase in computer power, both in terms of memory and speed, that has become available in the last seven or so years, the need to use large mainframe computers for long repetitive calculations has become less necessary. Programs have been available references (1,2) for the calculation of five degrees of freedom motions of a ship at speed in any given seaway, at the University for some years. The results from these programs have been validated for the vertical mode of motion both experimentally at model and full scale. With this in mind and also knowing the complexity of the vertical motion program module the task of converting the module to work on a microcomputer was undertaken.

The choice of microcomputer was narrow since if the program execution time was to be quick, it had to be written in a language that was capable of being compiled. Since the program was already written in FORTRAN and the department possesses a number of Apple 48K microcomputers which have been modified to use FORTRAN, the choice had been made virtually by default. The modifications to the Apple microcomputer are the addition of a Microsoft Z 80 card together with the CP/M operating system and Fortran assembler and compiler as supplied by Microsoft.

With this Apple system it is possible to break down the heave and pitch module into a number of smaller program modules that will each fit into the machine. In practice some of the programs call up the next program module automatically thus relieving the user of using system operating commands.

There are four program modules at present, GENSHIP, SHORT0, SHORT1, and SHORT2. Each module has a defined role and has had all its results validated.

GENSHIP

As the program title suggests it is used to generate the data file that is used for input to other programs. The program leads the user through the input data via questions and answers.

One point that is always worth bearing in mind is that the programs are written in FORTRAN. This program language differentiates between numbers called integers and real numbers. The former are used where the integer variable is required to be exactly represented by the computer memory, whereas the latter are represented by a binary approximation within the machine. The outcome of this is that when typing in data that is a real variable a decimal point is always required to be input. An example of this is displacement e.g. 1000.0. Each piece of input data is given the type of variable that it represents in the paragraph that follows.

Most data is self explanatory.

Input

1) Title. This is a set of eight characters that are used to specify files created on the data disk. The characters may be letters,numbers or spaces, the only condition is that the first character must be a letter.

2) Number of ship stations (Integer) either 11 or 21 are to be used. Station 1 is the fore perpendicular, 21 the aft perpendicular.

3) Units. It is possible to use either metric or imperial measure in the subsequent input data. The units are ,,

Metric	Tonnes,metres,seconds
Imperial	Tons, feet, seconds

4) Displacement (real), Is the displaced mass of the ship in the specified units.

5) Calculation type (integer). This allows choice of either the ship motions and/or the bending moments and shear forces in a seaway.

6) Weight properties (integer). It is possible to input the section properties in either mass or weight. For example in metric units these are tonnes or kilonewtons respectively.

7) Regular or irregular wave calculations (integer) are possible. If regular is chosen then wavelength is used as the building block for the ship response. If irregular is used then wave frequency is the building block. This then allows a spectral formulation of the ship's response to be calculated. It is not possible to use regular waves and then perform a spectral response.

8) Ship length (real) is the waterline length.

9) For each of the stations three or four pieces of data are input all are real.

a) Full section beam

b) Sectional area coefficient defined as sectional area divided by full beam and draft.

c) Draft of section to the waterline.

If bendings moments and shearing forces are required then

d) Section mass or weight as chosen.

If the sections weights have been input skip inputs 10,11.

10) Radius of gyration (real) in length units.

11) Longitudinal centre of gravity relative to midships (real), positive values are measured forwards.

Now skip cards 12,13,14.

When the bending moment and shearing force option has been specified the program automatically calculates these values at midships. It is possible to obtain these values at any of the other stations.

12) Initial station number (integer).

13) Final station number (integer).

14) Increment between the values in 12,13 above (integer)

If 12,13 are identical then input 14 should have a value of 1.

15) The statistical data can be presented as a spread spectra or not (integer).

16) Results can be presented in dimensional or non-dimensional form.

Heave is non-dimensionalised with respect to wave height.
Pitch is non-dimensionalised with respect to wave slope.
Bending moment is non-dimensionalised with respect to density, length squared and beam at midships.
Shearing force is non-dimensionalised with respect to density, length and midship beam.

The program generates one output file with the name of ship title together with the three character addition DAT. No output is expected from this program. It automatically starts the next module.

Channels used within the program are as follows

1) Screen

7) Output file XXXXXXXX.DAT

where XXXXXXXX is the ship title.

SHORTO

The function of this program is to check that the data input from GENSHIP is suitable for calculation and then proceeds to calculate the two dimensional properties (TDPs) of the sections. These are often termed the added mass and damping.

The program reads data from the file generated in GENSHIP and creates another file which contains the TDPs.

The only input information that is required for this program is the title of the ship previously used in GENSHIP, ie the eight characters used to describe the ship, including any spaces.

The first calculation that the program performs is to check that the ship is balanced. By this it is meant that the section data has a total displacement as that input. The program also checks the displacement by mass/weight if the section mass/weights have been input.

An error of 2% is allowed in either of these calculations.
All the input data is printed on the screen. If the ship is not balanced the program is stopped, then the user has to re-run GENSHIP again with corrected data. The same ship name can be used since the file will be overwritten.

When the ship data has been validated the program calculates the two dimensional properties using a Lewis transformation of the sections. A set of 25 non-dimensional frequencies are used for each of the sections, which are fixed within the machine.

Since each section data takes the order of 150 seconds to complete a message is printed as to the current state of the calculation.

Channels used

1 Screen

7 Input from file XXXXXXXX.DAT

8 Output to file XXXXXXXX.TDP

This program is by far the most costly in terms of computer memory and it has not proved possible within the constraints of a 48K system to load the next program module automatically. The program generates an output file containing certain switches for other calculations, number of sections, section beam, draft and area coefficient, and if used the section weight. The beam/draft ratio is also output as this is required in another module. This ratio may have been slightly modified to take account of criteria required for the Lewis Transformation; the bending moment stations, when required together with the radius of gyration and longitudinal centre of gravity. The section distances are also output, measured from the fore perpendicular. The array of non-dimensional frequencies at which the TDP's have been calculated, and finally for each section at each frequency the added mass and damping values.

SHORT1

To run this program type SHORT1 followed by pressing the return key.

This program solves the equations of motion for the frequencies/ wavelength that are specified, at user specified speeds and headings.

Data is read from the file generated by SHORTO, a data file is generated with the ships response at the frequencies specified.

Input

1) Output of the results can be either to the screen or the printer.
2) Input the eight character filename.
Depending upon the choice in GENSHIP of regular/irregular waves, the next three questions refer to wavelength or wave frequency (radians per second).

3) Initial wavelength/frequency (real)
4) Find wavelength/frequency (real)
5) Incremental wavelength/frequency (real).

It should be noted that only 50 wavelengths or frequencies are allowable. If this value is exceeded the program is stopped with a message

STOP IN PRELIMC. ERROR NO. N

The value of N is 1 if more than 50 frequencies have been specified.

If the initial frequency/wavelength is greater than the final frequency/wavelength then N=3.
Also if the incremental value of frequency/wavelength is less than or equal to 0.0 N=3.

6) Number of Ship Speeds (integer)
A maximum of 10 is allowable. If more than 10 is specified then the error message appears with N=0.

7) The ship speeds are input (real) one at a time, in knots, starting from the smallest and increasing to the largest.
If the initial speed is greater than the final speed, then the error message appears with N=4.

8) The initial wave heading of the ship to the waves (real). Head seas are taken as 180^{o}, following seas as 0^{o}. There is no need to calculate for wave angles exceeding 180^{o} as the motions are equivalent to that angle from 360^{o}. The angle value is input in degrees.

9) The final wave heading angle in degrees (real).

10) Incremental value of heading angle from initial to final (real)
Note that there is a maximum of 25 wave heading angles. If data values 8 , 9 are identical then 10 must be specified as 1.0.

Output

Output from the program consists of tables of the heave and pitch response of the ship at the specified speeds, headings and wavelengths/ frequencies. The phase angles of the motions are also output.

Phase is defined as follows, being relative to the maximum waveslope at midships. Heave is measured positively downwards, pitch as positive bow-up, and the wave positive is positive upwards. Thus for very long waves the phase angle is 180.0°, for heave motion.

If the bending moment and shearing forces have been calculated the results are tabulated with the heave and pitch at midships.

If bending moments and shearing force are calculated at stations other than midships, these results are written to file for later printout. These results are stored on file XXXXXXXX.BMS.

To print out these results type TYPE XXXXXXXX.BMS and either the return key for the values to be printed on the screen or control P and then return to echo the screen results to the printer.

The program also generates a file containing the heave and pitch motions as well as the bending moment and shearing forces, if specified, for use in the statistics package. These are contained on a file named XXXXXXXX.RES. No phase angle results have been stored.

Channels Used

1 Screen

2 Printer

7 Input from XXXXXXXX.TDP

8 Output to XXXXXXXX.RES

9 Output to XXXXXXXX.BMS

SHORT2

To run this program type SHORT2 followed by return.

This program calculates for specified spectra the variances and other statistical properties of the heave and pitch and the bending moment and shear force if specified. This program can only be used if irregular waves have been specified in GENSHIP.

If spread spectra have been specified in GENSHIP then the results are tabulated in this module.

Input

1) Hard copy output or not?

2) Ship file name as used in the previous programs.

3) Spectral type (integer)

Four types of spectra are available.

A) Newmann

B) Pierson-Moskowitz

C) Two Parameter I.T.T.C. or Bretschneider

D) J.O.N.S.W.A.P. as defined by the I.S.S.C.

4) Number of spectra (integer). A maximum of 10 is allowed.

5) A) For each spectrum the significant wave height.(real)

B) For either 3(C) or 3(D) the mean wave period T_o.

6) Whether the spectral ordinates are to be printed out or not.

It is recommended that these results are not printed out because of the large amount of paper wastage it causes.

Output

All speeds, headings and numberoof spectra the summary statistics are calculated. These being the mean square or variance, root mean square, average, $^{1}/_{3rd}$ highest, $^{1}/10$th highest, and the subjective motion parameter.

The spectral ordinates are output to file named XXXXXXXX.OUT. This contains data for future programs.

If the spread response switch has been invoked then the spread responses as a function of heading are also calculated.

Channels Used

1 Screen

2 Printer

7 Output to file XXXXXXXX.OUT

8 Input from file XXXXXXXX.RES

Running the Program

Switch the Apple microcomputer on, as well as the monitor and printer. This should cause a disc drive light to glow. Insert the ship motions program and close the disc drive door. After a few seconds the screen should display

A>

Type GENSHIP to run the suite of programs. The data disc is inserted into the other disc drive. To start a new data disc, the disc has to be first of all formatted and then have some operating programs written upon it. This is done as follows. Insert the disc marked MASTER into drive 1 or A. Insert the disc to be formatted in drive B. Now type FORMAT B: The process takes about 25 seconds. When it is finished press return then type COPY B:=A:/S. This takes about 10 seconds. Now remove MASTER from drive A and then insert the ship motions program disc. Press control C and this will cause the system to 'soft boot' i.e. take notice of change of disc in drive A. Then proceed as the beginning of this section.

References

1 Users Manual of Program AEW2, Ship Science Report, No 2,1976, P.A. Wilson.

2. Theory and computer program for calculation of the lateral motions of a ship, Ship Science Report No. 6/81,1981,P.A. Wilson.