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CALCULATION OF STATIC AND DYNAMIC CONFIGURATIONS OF A SINGLE POINT MOORING CABLE

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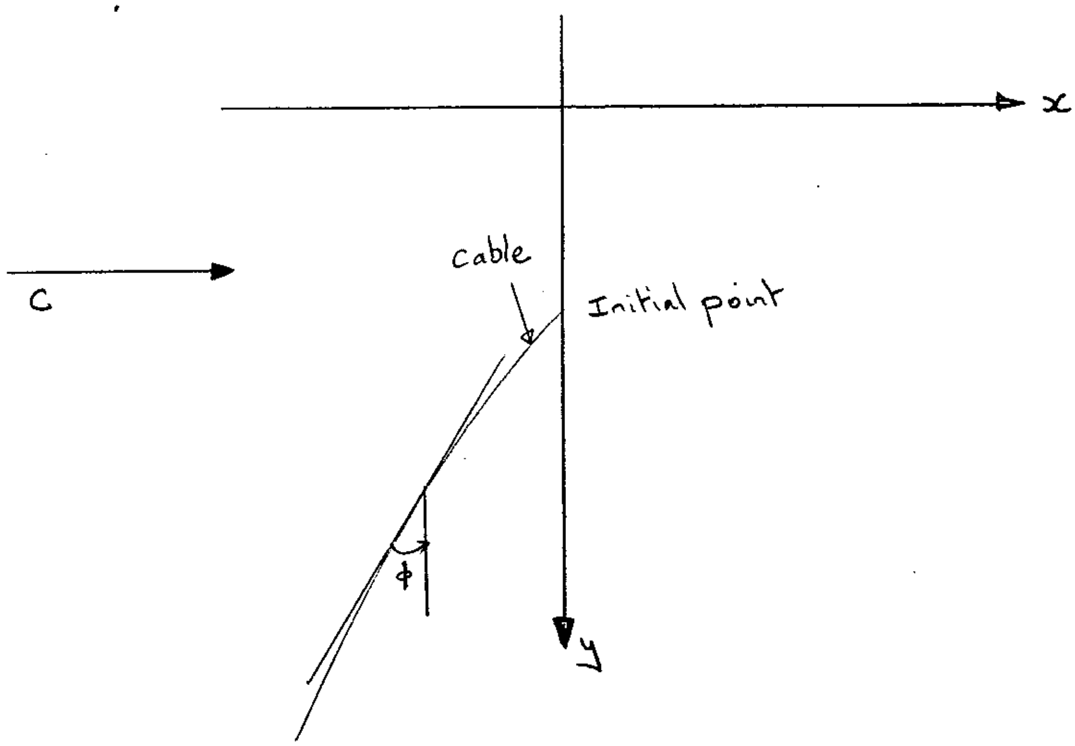
Cable Equations

The program calculates the configuration of the cable system in the presence of a steady state current alone, in the absence of time dependent excitations.

The differential equations for the steady-state configuration are well known and take the following form for the co-ordinate system as in figure 1, e.g. Berteaux*.



$$- T \frac{d\phi}{ds_o} + I + \sin \phi \; w = 0 \qquad \text{A}$$

$$\frac{dT}{ds_o} + G + \cos \phi \; w = 0 \qquad \text{B}$$

$$\frac{ds}{ds_o} = 1 + \varepsilon \qquad \text{C}$$

$$\frac{dx}{ds_o} = - (1 + \varepsilon) \sin\phi \qquad \text{D}$$

$$\frac{dy}{ds_o} = (1 + \varepsilon) \cos \phi \qquad \text{E}$$

where T = cable tension

ϕ = angle of the cable segment from the vertical

s_o = reference cable length ($T = T_o$), measured from initial point

T_o = reference tension

I, G = normal and tangential drag forces, per unit length, acting on the cable, respectively.

w = weight of the cable per unit length in the fluid.

s = stretched cable length measured from initial point

ε = cable strain, ($\varepsilon = 0$, $T = T_o$

x = horizontal displacement, +ve to the right

y = vertical displacement, +ve to downward

For smooth, approximately round cable, the normal and tangential drag may be taken as respectively proportional to the squares of the velocities normal and tangential to the cable.

Thus

$$I = \frac{1}{2} \rho\ C_D\ d\ C_n\ |C_n| \qquad 1$$

$$G = \frac{1}{2} \rho\ C_T\ d\ C_t\ |C_t| \qquad 2$$

where ρ is the fluid density

C_D, C_T normal and tangential drag coefficients

d cable diameter

C_n component of the current normal to the cable, C cosϕ

C_t component of the current tangential to the cable, C sinϕ

C magnitude of the current, acting in the x-direction only.

The tension strain function is assumed to be of the form

$$T = T_o + C_1\ \varepsilon^{C_2} \qquad 3$$

where C_1 constant of elasticity, C_1 = AE for linear elastic cable

A cross sectional area $\pi\ d^2/4$ for round cable

E modulus of elasticity

C_2 an exponent, $C_2 = 1$ for linear elastic model.

Thus equation 3 enables a non-linear tension strain relation to be modeled by only two input variables C_1 and C_2 It is often convenient to express ε as a function of $(T-T_o)$ in order to eliminate it from the cable equations (A→E)

Thus $$\varepsilon = \left(\frac{T-T_o}{C_1}\right)^{1/C2} \qquad 4$$

Intermediate Bodies

In the integration of the conditions at the top of the cable, it is assumed that these are known; the integration of the cable equations proceeds down the cable. To allow for discontinuities in the cable, the integration procedure must be interrupted, and the unknown cable variables T_u, ϕ_u below the body must be related to the known variables T_k, ϕ_k above the body. For two dimensional cases the equations become

$$T_u = \sqrt{((\sin\phi_k)\ T_k + D_x)^2 + (-T_k\ \cos\phi_k + W_B)^2} \qquad 5$$

$$\phi_u = \tan^{-1}\left\{\frac{\sin\phi_k\ T_k + D_x}{\cos\phi_k\ T_k + W_B}\right\} \qquad 6$$

where D_x = the drag on the body

W_B = the weight of the body in the fluid

$$D_x = \frac{1}{2}\ \rho\ C_D\ A_x\ c|c| \qquad 7$$

$C_D\ A_X$ is the drag area of the body for the flow in the x-direction.

Boundary Conditions

The integration of the differential equations is most convenient when the tension T and the angle ϕ are known at one end of the cable. These will be known for certain cases of single-point moored cables and towing cables. For the moored cases, the program starts with the known condition at the top of the cable and integrates the five differential equations until the lower end of the cable is reached. This is the simplest case for the program, since the numbering of the cable segments starts at the top. For towing cables, where the conditions are known at the lower towed end, the program integrates the equation twice. They are first integrated from the towed body to the upper point, thus fixing the conditions at this point. Then in order to conform to the numbering system which is used for the dynamic calculation, the equations are integrated once again from the upper point down to the lower towed body.

In many applications, the values of T and ϕ are not known à priori at any point along the cable. It is necessary to treat these cases as boundary value problems and use iteration techniques to obtain the solution.

The program contains two iteration schemes of particular interest to sonobuoy systems.

A. A cable of given length moored in a given ocean depth.

B. A free floating cable system.

It is possible ...

For a long wave, according to linear theory, the wave particles prescribe the following motion

$$x_w = a\, e^{-ky} \cos (kx - \omega t + \theta) \qquad \text{8a}$$

$$y_w = -\, a\, e^{-ky} \sin (kx - \omega t + \theta) \qquad \text{8b}$$

where x_w, y_w are the water particle displacement

- a is the wave amplitude
- k is the wave number $= 2\pi/\lambda$
- λ is the wavelength
- ω is the radian frequency $= 2\pi f = \sqrt{2\pi g/\lambda}$ for long waves

f	is the wave frequency
t	is time
g	is gravity constant
θ	is the wave phase angle

For an irregular sea consisting of N distinct components, the resultant water particle displacement are obtained as

$$x_W = \sum_{i=1}^{N} a_i \, e^{-k_i y} \cos (k_i x - \omega_i t + \theta_i) \qquad 9a$$

$$y_W = -\sum_{i=1}^{N} a_i \, e^{-k_i y} \sin (k_i y - \omega_i t + \theta_i) \qquad 9b$$

The program allows the user to specify the irregular seaway in one of two ways.

1. By specifying N, k_i, θ_i, a_i for 9a and 9b

2. By using a known energy spectrum $S(\omega)$

The latter defines the wave amplitudes as

$$a_i = \sqrt{S(\omega_i)\Delta\omega} \qquad 10$$

where $\omega_i = \omega_{i-1} + \Delta\omega$

$\Delta\omega = (\omega_u \mp \omega_L)/N$

ω_u is the upper limit of ω's

ω_L is the lower limit of ω's

The program uses $S(\omega) = \frac{A}{\omega^5} e^{-B/\omega^4}$ 11

where $A = 0.0081\, g^2$, $B = 33.56\, h_{\frac{1}{3}}{}^2$, where $h_{\frac{1}{3}}$ is the significant wave height in feet. The values of θ_i are evenly spaced from θ_1 to $360 + \theta_1$ degrees.

Prescribed Surface Motions

The program allows the user to prescribe the motion at the surface or to describe it by means of differential equations of motion for a surface buoy.

If the surface buoy or ship is sufficiently large that its motions are not appreciably affected by the presence of the cable, these motions may be calculated separately and used as input for the present program.

The program considers the prescribed motion of the upper end of the cable as composed of a series of sinusoidal components in the horizontal and vertical direction

$$x_s = \sum_{i=1}^{m} a_{xi} \cos (- \omega_i t + \phi_i) \qquad 12a$$

$$y_s = \sum_{i=1}^{m} - a_{yi} \sin (- \omega_i t + \phi_i) \qquad 12b$$

where x_s, y_s are the horizontal and vertical components of the surface motion

a_{xi}, a_{yi} are the amplitudes of the i^{th} component of x_s, y_s
ω_i, ϕ_i are the frequency and phase angle of the i^{th} component.

It is equally as easy to prescribe any analytic function of time in the program.

Dynamic Cable Equations

When the mooring cable is connected to a surface buoy the added mass coefficients of the surface buoy are in general functions of frequency. In the time domain, which is obviously where the solution should be, this requires the solution of integrodifferential equations, which usually contain convolution integrals. If the frequency dependant coefficients are expressed as simple polynomials of the frequency, then the integrodifferential equations may be replaced by a set of higher order differential equations. In either case the solutions are costly. Thus usually the surface buoy motions have been solved in the frequency domain, then to give the response in the sea spectrum the principle of linear superposition is used. The one big failure of this method is that it fails to predict the large dynamic snap loads which occur when the load goes slack.

As the prediction of dynamic loads is of paramount importance, the frequency domain method was not used. To give some credence to the time domain approach, only spar buoys and small surface buoys are allowed, because their added mass and damping values are essentially those of infinite fluid.

There are two main methods of solution of this problem in the time domain, (1) by the method of characteristics; (2) by the finite element method. The main drawback of the method of characteristics is that it requires unusually long computation times.

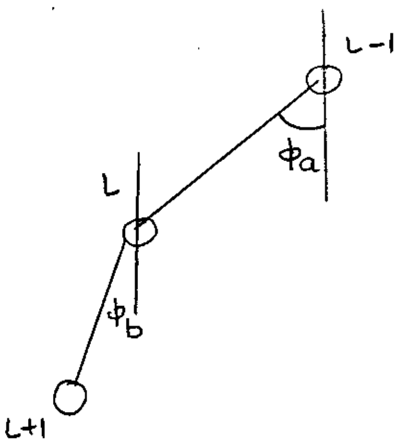
The finite element method seeks to represent the actual cable system by a series of segments and nodes. The set of partial differential equations is then reduced to a set of ordinary differential equations of motion of the nodes.

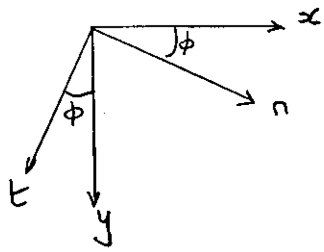
The method has much flexibility allowing the user to choose the number and location of nodes. Only straight element nodes are used.

Formulation of Equations of Motion

The two unknowns are the inclination and stretch of the cable element, with all the forces defined in terms of the tangential and normal directions. The major problem is the presence of intermediate bodies along the cable, for which the inertia and drag are most conveniently expressed in the spatial x and y directions.

The cable is divided into a number of massless straight elastic segments. The inertia, weight, and drag forces acting on each cable segment are equally divided between the two nodes at the ends of the segment.





The two second order differential equations of motion of the node i, in the x-y coordinate system are :

$$J_x \ddot{x} + K_i \ddot{y} = F_x = T_x + D_{Nx} + D_{tx} + D_{Bx}$$

$$K_i \ddot{x} + J_y \ddot{y} = F_y = T_y + D_{Ny} + D_{ty} + D_{By} + W_c + W_B$$

for all cable elements i = 1, ... M

where

J_x, J_y, K_i are the inertia coefficients defined below

x, y subscripts denoting x, y direction

F sum of all forces acting at the node

T tension of the cable due to stretch and internal damping

D_n normal drag force acting on the cable

D_t tangential drag force acting on the cable

W_c weight of cable in the fluid

W_B weight of the intermediate body in the fluid

M total number of nodes

Decoupling the above two equations to give

$$\ddot{x} = (J_y F_x - K F_y) / (J_x J_y - K^2)$$

$$\ddot{y} = (J_x F_y - K F_x) / (J_x J_y - K^2)$$

Definition of Cable Forces

Each cable element is taken to be a long thin cylinder for which fluid inertia is added only for acceleration normal to the segment.

$$F = \left[\left(\frac{\mu_a\ l_{oa} + \mu_b\ l_{ob}}{2} + \frac{\alpha\ \rho\ A_a\ l_{ca}}{2}\cos^2\phi_a + \frac{\alpha\ \rho\ A_b\ l_{ob}}{2}\cos^2\phi_b\right.\right.$$

$$\left. + M_{BVx}\right)\ \ddot{x}$$

$$\left. + \left(-\frac{\alpha\ \rho\ A_a\ l_{oa}}{2}\sin\phi_a\ \cos\phi_a - \frac{\alpha\ \rho\ A_b\ l_{ob}}{2}\sin\phi_b\ \cos\phi_b\right)\ \ddot{y}\right] \underset{\sim}{i}$$

$$+\left[\left(-\frac{\alpha\ \rho\ A_a\ l_{oa}}{2}\sin\phi_a\ \cos\phi_a - \frac{\alpha\ \rho\ A_b l_{ob}}{2}\sin\phi_b\ \cos\phi_b\right)\ \ddot{x}\right.$$

$$+\left(\frac{\mu_a\ l_{oa} + \mu_b\ l_{ob}}{2} + \alpha\ \rho\ A_a\ l_{oa}\ \sin^2\phi_a + \alpha\ \rho\ A_b\ l_{ob}\ \sin^2\phi_b + \right.$$

$$\left.\left. M_{BVy}\right)\ \ddot{y}\right]\ \underset{\sim}{j}$$

$$= \left[J_x\ \ddot{x} + K\ddot{y}\right] \underset{\sim}{i} + \left[K\ddot{x} + J_y\ \ddot{y}\ \right]\ \underset{\sim}{j}$$

where the subscripts a, b denote the cable segments above and below the node. M_{BVx}, M_{BVy} are the virtual mass of the intermediate body in the x,y directions.

The tension forces for an extensible cable segment, depends upon the strain ε, and the strain rate $\dot{\varepsilon}$.

$$\varepsilon = \frac{\Delta \ell}{\ell_o} = \frac{\ell}{\ell_o} - 1 = \frac{\sqrt{(x_\ell - x_u)^2 + (y_\ell - y_u)^2}}{\ell_o} - 1$$

$$\dot{\varepsilon} = \frac{d\varepsilon}{dt} = \frac{(\dot{x}_\ell - \dot{x}_u)\ (\dot{x}_\ell - x_u) + (\dot{y}_\ell - \dot{y}_u)\ (u_\ell - y_u)}{\ell\ \ell_o}$$

where ℓ is the stretched length of the cable segment, and the subscripts ℓ, t u refer to the lower and upper ends of the cable segment.

The general relationship for tension that is used is

$$T = T_o + C_1 \varepsilon^{C_2} + C_I \dot{\varepsilon}$$

where C_I is the internal damping coefficient.

Since the cable segments above and below act on the node, then

$$T_x = T_a \sin\phi_a - T_b \sin\phi_b$$

$$T_y = -T_a \cos\phi_a + T_b \cos\phi_b$$

The drag forces on the cables are proportional to the relative velocities normal, and tangential to the cable.

$$V_{rn} = (C + \dot{x}_w - \dot{x}) \cos\phi + (\dot{y}_w - \dot{y}) \sin\phi$$

$$V_{rt} = - (C + \dot{x}_w - \dot{x}) \sin\phi + (\dot{y}_w - \dot{y}) \cos\phi$$

If one half of the drag forces acting on the cable segments above and below the node are summed, then

$$D_{nx} = \frac{1}{2} D_{na} \cos\phi_a + \frac{1}{2} D_{nb} \cos\phi_b$$

$$D_{ny} = \frac{1}{2} D_{nb} \sin\phi_a + \frac{1}{2} D_{nb} \sin\phi_b$$

$$D_{tx} = - \frac{1}{2} D_{ta} \sin\phi_a - \frac{1}{2} D_{tb} \sin\phi_b$$

$$D_{ty} = \frac{1}{2} D_{ta} \cos\phi_a + \frac{1}{2} D_{tb} \cos\phi_b$$

with

$$D_n = \frac{1}{2} \quad C_D \; d \; \ell_o \; V_{rn} \; |V_{rn}|$$

$$D_t = \frac{1}{2} \quad C_T \; d \; \ell_o \; V_{rt} \; |V_{rt}|$$

$$V_{rn} = \dot{x}_r \cos\phi \; + \dot{y}_r \sin\phi$$

$$V_{rt} = - \dot{x}_r \sin\phi + \dot{y}_r \cos\phi$$

where the subscript a, or b can be applied to the above four equations.

INPUT.

Card 1 N CASES FORMAT (I3)

This allows different number of current profiles to be input N CASES $\geq$ 1

Card 2 TITLE FORMAT (20A4)

Title of the job. This has to appear on one card.

Card 3. NSM, NSW, NCAB, NCUR, ITER, MTRC. FORMAT (6I3)

NSM number of surface motion components $\leq$ 20

NSW number of surface wave components $\leq$20

NCAB number of cable segments 2 $\leq$ NCAB $\leq$ 50

NCUR number of current profiles 2 $\leq$ NCUR $\leq$ 10

MTRC $\geq$ 1 metric units, $\leq$ 0 Imperial units

ITER iteration index.

ITER = 0, no iteration (prescribed initial steady state card)

1, free floating cable system

2, moored cable with given length in given depths

Card 4 FSM(K), K = 1, NSM FORMAT (8F10.4)

Frequencies of surface motion in Hz.

N.B. is 2000 > FSM(1) $\geq$ 1000, the program takes the prescribed surface motion components equal to the surface wave components by setting FSM(K) = FRSW(K), AXSM(K) = AYSM(K) = ASW(K), FIDSM(K) = FIDSW(K), for K = 1, to NSM, and automatically NSM = NSW.

if 3000 > FSM ≥ 2000, the program accepts input data for a spar buoy and considers AXSM(K) to be the cross sectional area of the buoy at depth AYSM(K) below the surface. AYSM(1) = O, and AYSM(NSM) = total draught under the combined action of the buoy weight in air and the vertical component of the steady state tension. NSM should be odd.

if FSM ≥ 3000, the program accepts input data for a spheroidal buoy and considered AXSM(1) to be the radius of the buoy cross-section at the free surface, AXSM(1) to be the draught. The rest of the input values AXSM(K), AYSM(K), FIDSM(K), K = 2, ... can take any value, e.g. O

<u>Card 5</u> AXSM(K), K = 1, NSM FORMAT (8F10.4)

These are the amplitude of the horizontal surface motion.

<u>Card 6</u> AYSM(K), K = 1,NSM FORMAT (8F10.4)

These are the amplitudes of the vertical surface motion.

<u>Card 7</u> FIDSM(K), K = 1 NSM FORMAT (8F10.4)

These are the phase angles of the surface motion components.

<u>Card 8</u> ASW(K), K = 1 NSW FORMAT (8F10.4)

These are the amplitude of the surface wave components

if ASW(1) > 1000, the program computes the amplitude of the NSW surface wave components by using the Pierson Moskowitz sea spectrum. The program considers the significant wave height to be (ASW(1) - 1000), and FRSW(1), and FRSW(2) to be the upper and lower frequencies of the sea spectrum in Hz. The program internally generates the phases of the wave components by considering them to be uniformly separated by 360/NSW degrees. The phase of the lowest frequency is FIDSW(1).

Card 9 FRSW(K), K = 1, NSW FORMAT (8F10.4)

The frequency components in Hz of the surface waves.

Card 10 FIDSW(K), K = 1, NSW FORMAT (8F10.4)

The phase of the surface wave components.

Card 11 RHO, SUBM, TWX, TIY, CDASX, AMC, AFAC, TMIN FORMAT (8F10.4)

RHO fluid density in slug / ft^3 (Kg / m^3)

SUBM submergence of top point of cable below free surface

TWX horizontal force acting at top of cable

TIY vertical component of tension at top of cable

CDASX drag area of surface buoy perpendicular to the x-axis

AMC added mass coefficient of cable, 1.0 for round cable

AFAC cross-section area of cable = AFAC $\frac{*\pi d^2}{4}$, AFAC = 1 for round

TMIN minimum algebraic tension which can be supported

N.B. For the case of the surface buoy, the program calculates the drag acting on the surface buoy due to the ocean current by taking the value of the current at SUBM units below the surface.

The total horizontal at the top point of the cable

TIX = TWX + $\frac{1}{2}\rho$ *CDABX*CCF(SUBM)*ABS(CCF(SUBM))

In the cases where there is no surface buoy (i.e. prescribed motion), TWX and / or CDASX may be set equal to zero. For surface buoys, TWX represents the wind loading.

Card 12 TINV1, DT1, TOTT, DT2, DIR, TBH, TBYMX FORMAT (8F10.4)

TINV1 initial time interval in seconds for dynamic calculations

DT1 time step in seconds for which print out is required $0<t \leq$ TINV1

TOTT total time interval for which dynamic calcs are required

DT2 time step in seconds for printout TINV1 $< t \leq$ TOTT

DIR, DIR < 0 if the initial conditions are special at the bottom (e.g. towed cable), otherwise DIR $\geq$ 0.

TBH applied force on lower weight body NCAB-1, in x direction

TBYMX maximum absolute value of tension in cable just below buoy for buoy-cable system set TBYMX = to say 99999.

Card 13 FLC(K), K = 1,NCAB FORMAT (8F10.2)

length of K^{th} cable segment

Card 14 DCI(K), K = 1,NCAB FORMAT (8F10.4)

Diameter of K^{th} cable segment in inches (cms)

Card 15 CDN(K), K = 1, NCAB FORMAT (8F10.4)

Normal drag coefficient of K^{th} cable segment

Card 16 CDT(K), K = 1, NCAB FORMAT (8F10.4)

Tangential drag coefficient of K^{th} cable segment

Card 17 WC(K), K = 1, NCAB FORMAT (8F10.4)

Weight in fluid of the K^{th} cable segment at the reference cable tension

Card 18 CM(K), K = 1, NCAB FORMAT (8F10.6)

Mass of K^{th} cable segment at the reference cable tension

Card 19 TREF(K), K = 1 NCAB FORMAT (8F10.2)

Reference cable tensions of the K^{th} cable segment

Card 20 C1(K), K = 1, NCAB FORMAT (8F10.0)

The reference coefficient as in

$$\text{Tension} = \text{TREF(K)} + \text{C1(K)}*\varepsilon^{\text{C2(K)}} + \text{CINT(K)}*\dot{\varepsilon}$$

for linear elasticity C1 = AE, C2 = 1.

Card 21 C2(K), K = 1, NCAB FORMAT (8F10.4)

Exponents of non-linear elasticity for K^{th} segment

Card 22 CINT(K), K = 1, NCAB FORMAT (8F10.4)

Internal damping values for rate of elasticity.

Card 23 WBD(K), K = 1, NCAB FORMAT (8F10.4)

Weight in fluid of the K^{th} body

Card 24 CDABX(K), K = 1, NCAB FORMAT (8F10.4)

Drag area of K^{th} body for flow in x-direction.

Card 25 CDABY(K), K = 1, NCAB FORMAT (8F10.4)

Drag area of K^{th} body for flow in y-direction.

Card 26 XMBV(K), K = 1, NCAB FORMAT (8F10.4)

Virtual mass mass (mass + added mass) of K^{th} body in x-direction.

Card 27 YMBV(K), K = 1, NCAB FORMAT (8F10.4)

Virtual mass of K^{th} body in y-direction.

Card 28 YY(K), K = 1, NCUR FORMAT (8F10.2)

Value of y in feet of a current profile.

Card 29 PHID(K), K = 1, NCAB FORMAT (8F10.4)

Initial value of ϕ of K^{th} cable element in degrees

Card 30 TENI(K), K = 1, NCAB, FORMAT (8F10.2)

Initial tension of K^{th} segment

Card 31 XPI(K), K = 1, NCAB FORMAT (8F10.2)

Initial value of $\dot{x}$ of K^{th} node.

Card 32 YPI(K), K = 1, NCAB FORMAT (8F10.4)

Initial value of $\dot{y}$ of K^{th} node.

Card 33 CCK(I), K = 1, NCUR FORMAT (8F10.4)

These are the velocities of the current in knots (m/s) at the points on card 28.

The card 33 is repeated for as many current profiles as card 1 says.

If the surface float is a buoy then two extra cards are needed.

Card 34 CDASY, WAS, RWY, RTX, RTY, YCG, BIN

CDASY Drag area in the y-direction

WAS Weight in air

RWY Vertical distance of wind loading centre of pressure from buoy centre of gravity YCG

RTX, RTY (x,y) distance of cable attachment point from YCG.

YCG The distance of centre of gravity below the free surface under the action of its own weight in air WAS, and the vertical component of the steady state tension - TIY.

BIN Moment of inertia in air about YCG

XSI, ZETI, SYDI, Initial values of (x, ζ, ψ) where ζ is the vertical displacement of the centre of gravity from the equilibrium value YCG.

XPSI, ZTPI, SYPDI Initial values of $(\dot{x}, \dot{\zeta}, \dot{\psi})$

Sample problems and their solutions follow.

All units in the program are in ft (metres) and slugs (kgm) except where stated explicitly.

```
PROBLEM 1D C1=24000,C2 =1
  1  1  5  2  0
 0.1
 10.0
   10.0
   0.0
   10.0
   0.1
   0.0
 1.94        0.0          0.0        -50.0       0.0         1.0        1.0
   10.0          0.25          50.0      1.0       -1.0       0.0      99999.0
 250.0       250.0       250.0        250.0        500.0
 0.2          0.2        0.2        0.2
 1.4          1.4         1.4         1.4        0.0
 0.02        0.02        0.02        0.02        0.0
  0.01        0.01       0.01        0.01
 0.001       0.001       0.001       0.001
 25.0        25.0        25.0         25.0
 24000.0       24000.0  24000.0   24000.0
   1.0        1.0         1.0         1.0        1.0
 0.0
  0.0         0.0         0.0        20.0
  0.0         0.0         0.0         0.3
  0.0         0.0         0.0         0.3
  0.0         0.0         0.0         1.0
  0.0         0.0         0.0         1.0
 0.0          10000.0
 999.0
 0.0
 0.0
 0.0
   1.0        1.0
```

```
PROBLEM 1D ,C1=24000.0 ,C2=1.0
                              .10        10.00        0.00      512.48      .0123
                             0.00        1.00
                         10000.00        1.00

FLUID DENSITY=     1.9400 SL/CUFT
                            .1000     10.0000     10.0000     0.0000
    1    250.00    .2000    1.4000    .0200    .0100 .001000       25.00
    2    250.00    .2000    1.4000    .0200    .0100 .001000       25.00
    3    250.00    .2000    1.4000    .0200    .0100 .001000       25.00
    4    250.00    .2000    1.4000    .0200    .0100 .001000       25.00
    5    500.00   0.0000    0.0000   0.0000   0.00000.000000        0.00
      0.0000         0.0000          0.0000   99999.0000
XA=          10.0000YA=           0.0000XPA=            0.0000YPA=

TIX=          .83        TIY=       20.00   DIRECTION=        -1.00
    0        0.00        0.00       10.00        0.00       20.02      177.63
    4      125.00      125.02      -17.98     -121.18       21.24      157.34
    4      250.00      250.04      -80.75     -228.93       22.34      143.20
    3      250.00      250.04      -80.75     -228.93       22.34      143.20
    3      375.00      375.05     -163.86     -322.13       23.33      134.02
    3      500.00      500.06     -258.44     -403.78       24.21      127.99
    2      500.00      500.06     -258.44     -403.78       24.21      127.99
    2      625.00      625.06     -359.77     -476.93       25.02      123.92
    2      750.00      750.06     -465.29     -543.92       25.77      121.07
    1      750.00      750.06     -465.29     -543.92       25.77      121.07
    1      875.00      875.07     -573.55     -606.41       26.48      119.02
    1     1000.00     1000.08     -683.68     -665.55       27.16      117.52
    0     1000.00     1000.08     -683.68     -665.55       27.16      117.52

REVISED VALUE OF WIND LD=      -24.0854 LB
XA=          10.0000YA=           0.0000XPA=            0.0000YPA=

TIX=       -24.09        TIY=      -12.55   DIRECTION=         1.00
    0        0.00        0.00       10.00        0.00       27.16      -62.48
    1      125.00      125.01      120.13       59.14       26.48      -60.98
    1      250.00      250.02      228.39      121.63       25.77      -58.93
    1      250.00      250.02      228.39      121.63       25.77      -58.93
    2      375.00      375.02      333.91      188.62       25.02      -56.08
    2      500.00      500.02      435.24      261.77       24.21      -52.01
    2      500.00      500.02      435.24      261.77       24.21      -52.01
    3      625.00      625.03      529.82      343.42       23.33      -45.98
    3      750.00      750.04      612.93      436.62       22.34      -36.80
    3      750.00      750.04      612.93      436.62       22.34      -36.80
    4      875.00      875.05      675.70      544.37       21.24      -22.66
    4     1000.00     1000.08      703.68      665.55       20.02       -2.37
    4     1000.00     1000.08      703.68      665.55         .00       93.41
    5     1250.00     1279.58      424.07      648.91         .00       93.41
    5     1500.00     1559.09      145.66      632.27         .00       93.41
    5     1500.00     1559.09      145.66      632.27         .00       93.41
    1     -60.9757       26.48      228.62      121.30      0.0000      0.0000
    2     -58.0834       25.02      436.08      260.80      0.0000      0.0000
    3     -45.9844       23.33      615.85      434.50      0.0000      0.0000
    4     -22.6616       21.24      712.16      665.16      0.0000      0.0000
    5      93.4129         .00      154.14      631.88      0.0000      0.0000

WAVE   .2500 .003906        9.88        1.56      -.9829      6.2058      -3.
    0  .2500 .003906        9.88        1.56      -.9829      6.2058
    1  .2500 .003906      229.26      121.29      2.7698      -.1749     -11.
    2  .2500 .003906      436.36      261.06      2.0476      1.6085     -11.
    3  .2500 .003906      615.99      434.64      1.7831      1.7836       4.
    4  .2500 .003906      712.16      665.18       .1843       .5736       5.

WAVE   .5000 .001953        9.51        3.09     -1.9416      5.9757      -3.
    0 5.0000 .015625      -10.00         .00      -.0000     -6.2832
    1 5.0000 .015625      213.01      113.17     -3.4522      -.0670       3.
    2 5.0000 .015625      422.37      249.90     -2.3287     -2.1667       2.
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