Hand-Held Calculator Algorithms for Coastal Engineering

by

Todd L. Walton, Jr., William A. Birkemeier,
and J. Richard Weggel

COASTAL ENGINEERING TECHNICAL AID NO. 82-1

JANUARY 1982

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER CETA 82-1	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) HAND-HELD CALCULATOR ALGORITHMS FOR COASTAL ENGINEERING		5. TYPE OF REPORT & PERIOD COVERED Coastal Engineering Technical Aid
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Todd L. Walton, Jr., William A. Birkemeier, and J. Richard Weggel		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Department of the Army Coastal Engineering Research Center (CEREN-EV) Kingman Building, Fort Belvoir, Virginia 22060		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS C31181
11. CONTROLLING OFFICE NAME AND ADDRESS Department of the Army Coastal Engineering Research Center Kingman Building, Fort Belvoir, Virginia 22060		12. REPORT DATE January 1982
		13. NUMBER OF PAGES 71
14. MONITORING AGENCY NAME & ADDRESS (If different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)		
<div style="display: flex; justify-content: space-between;"> <div> <u>Calculator algorithms</u> <u>Coastal engineering</u> </div> <div> <u>Wave generation</u> <u>Wave transformations</u> </div> </div>		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)		
<p>This report provides algorithms for a number of calculator programs useful in performing coastal engineering calculations, primarily in the area of wave transformations and wave generation. Six programs are included with different versions for use with hand-held calculators which employ either the Reverse Polish Notation (RPN) or the Algebraic Operating System (AOS). These programs can be used to compute linear wave parameters, orbital velocities, breaking wave height and direction, shallow-water wave forecasts, depth-limited breaking wave height, and wave transmission past a vertical barrier.</p>		

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PREFACE

This report provides coastal engineers algorithms for a number of hand-held calculator programs for coastal engineering, primarily in the area of wave transformations and wave generation. These algorithms were developed under the coastal engineering research program of the U.S. Army Coastal Engineering Research Center (CERC).

The report was written by Dr. Todd L. Walton, Jr., Hydraulic Engineer; William A. Birkemeier, Hydraulic Engineer; and Dr. J. Richard Weggel, Chief, Evaluation Branch, Engineering Development Division.

The authors acknowledge the assistance of A. Fromer and K. Stacy in preparing the manuscript. Reviews by R.A. Jachowski and Dr. R.J. Hallermeier of CERC and Dr. G. Oertel of Old Dominion University were appreciated.

Comments on this publication are invited.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.

TED E. BISHOP
Colonel, Corps of Engineers
Commander and Director

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CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	by	To obtain
inches	25.4	millimeters
	2.54	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	30.48	centimeters
	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.0283	cubic meters
yards	0.9144	meters
square yards	0.836	square meters
cubic yards	0.7646	cubic meters
miles	1.6093	kilometers
square miles	259.0	hectares
knots	1.852	kilometers per hour
acres	0.4047	hectares
foot-pounds	1.3558	newton meters
millibars	1.0197×10^{-3}	kilograms per square centimeter
ounces	28.35	grams
pounds	453.6	grams
	0.4536	kilograms
ton, long	1.0160	metric tons
ton, short	0.9072	metric tons
degrees (angle)	0.01745	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins ¹

¹To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula: $C = (5/9) (F - 32)$.

To obtain Kelvin (K) readings, use formula: $K = (5/9) (F - 32) + 273.15$.

HAND-HELD CALCULATOR ALGORITHMS FOR COASTAL ENGINEERING

by
Todd L. Walton, Jr., William A. Birkemeier, and J. Richard Weggel

I. INTRODUCTION

The advent of the hand-held programable calculator has led to the development of numerous programs in various fields of engineering and science. Coastal engineering is no exception. This report provides algorithms for a number of calculator programs useful in performing coastal engineering calculations, primarily in the area of wave transformations and wave generation.

There are basically two types of hand-held programable calculators: those that use algebraic logic, such as Texas Instruments, Algebraic Operating System (AOS) notation, and those that use Reverse Polish Notation (RPN), such as Hewlett-Packard. For the six programs presented herein, versions in each type of notation are provided--AOS designated by "A" and RPN designated by "R." Each program is documented, the assumptions are briefly described, and references to more detailed presentations of the theory are given.

Since subtle differences exist among various brands of calculators and among various models by the same manufacturer, the programs presented may need to be modified to adapt them to other brands or models. These programs were prepared and checked, using the Texas Instruments TI-59 (AOS) and the Hewlett-Packard HP67 (RPN). Users should refer to the operating manuals supplied with individual calculators. Algorithms may be set up specifically to meet some limiting conditions. For example, some programable calculators have a limiting restriction on the number of program steps accepted so a program must be revised to meet the limitation. The Texas Instruments TI-57, for example, accepts only 50 program steps. Algorithms may be adapted to meet this limitation by requiring prior calculation of input parameters either manually or by another program.

Each of the AOS programs incorporates TI-59 compatible print routines which print and label all input and output parameters. The user only has to enter the input parameters and the results are automatically computed and printed. Since the printing routines increase program length by as much as 25 percent, use of a magnetic card for permanent program storage is recommended. All print steps are marked with asterisks and need not be entered if printing is not desired.

II. PROGRAMS

Six programs (100, 101, 102, 103, 104, and 105) are presented in this report. Program 100, a simple program that computes linear wave theory wavelength for a given depth, is designed to be used as the basis for any program that requires wavelength; in fact, it has been incorporated into programs 101, 102, and 105.

Program 101 is another basic program which computes not only wavelength but also a number of other linear wave theory parameters. This program forms the basis for program 102 and can be adapted to other programs as well.

Program 102 computes linear wave parameters and breaking wave height and direction based on nearshore or deepwater wave information. Program 103 can be used to forecast wave height and period in shallow water. Program 104 and 105 address wave conditions at structures--program 104 predicts the depth-limited design breaking wave height at a structure; 105 uses Fuch's equation to predict wave transmission over a thin barrier.

Each program allows either English or metric input and output (the AOS programs print an "M" when metric is selected). Program listings are annotated, making it possible to follow the logic of the algorithm and to make modifications if desired.

There are undoubtedly many calculator programs not included here that have been developed on coastal engineering subjects. Practicing engineers who would like to disseminate such programs (in either AOS or RPN) to other users are encouraged to submit them to the Coastal Engineering Research Center (CERC). If the response is great enough, additional reports presenting the programs will be prepared. Comments, programs, or suggestions for programs should be sent to:

Commander and Director
US Army Coastal Engineering Research Center
ATTN: Evaluation Branch
Kingman Building
Fort Belvoir, VA 22060

These programs and future programs will generally correspond to the following numbering scheme:

Miscellaneous	0-99
Waves and currents	100-299
Inlets	300-499
Beaches	500-699
Geology	700-899
Structures	900-1099

In general, the documentation of programs submitted should be in a format paralleling that of the programs presented in this report. A blank set of forms which can be reproduced is included in the Appendix.

Program Description

Program Title	100R Linear Wave Theory Wavelength (RPN logic)		
Name	J.R. Weggel	Date	12/80
Address	Coastal Engineering Research Center		
City	Kingman Building	State	Virginia
	Fort Belvoir,	Zip Code	22060

Program Description, Equations, Variables, etc.

This algorithm takes deepwater wavelength as input and using the depth at a given site iterates to obtain wavelength by linear wave theory. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER,
Shore Protection Manual, 3d ed., Vol. I, Eq. (2-4), Stock No. 008-
002-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings

100R-1

User Instructions

Program Title: 100R Linear Wave Theory Wavelength (RPN logic)

[illegible]

100R-2

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	FLBLA	31 25 11	ENTER T		RCL 2	34 02	
	STO 7	33 07	T → R7		GTO D	22 14	
	3	03			FLBLE	31 25 15	
	2	02		060	RCL 2	34 02	
	.	83			RLS	84	
	2	02			2RLFa	32 25 11	
	STO 6	33 06	g(ENGLISH) → R ₆		STO 7	33 07	
	FLBLB	31 25 12			9	09	
	RCL 7	34 07			.	83	
010	2 x ²	32 54			B	08	
	RCL 6	34 06			1	01	
	x	71			STO 6	33 06	
	2	02			GTO B	22 12	
	÷	81					
	h π	35 13					
	÷	81					
	STO 1	33 01	L ₀ → R ₁				
	RLS	84					
	FLBLC	31 25 13					
020	2	02					
	x	71					
	h π	35 13					
	x	71					
	STO 5	33 05	2πd → R ₅				
	RCL 1	34 01					
	FLBLD	31 25 14					
	STO 3	33 03					
	h Yx	35 62					
	RCL 5	34 05					
030	x	71	2πd → R ₄				
	STO 4	33 04	L ₀ → R ₄				
	2 e ^x	32 52					
	RCL 4	34 04					
	CHS	42					
	2 e ^x	32 52					
	-	51					
	RCL 4	34 04					
	2 e ^x	32 52					
	RCL 4	34 04					
040	CHS	42					
	2 e ^x	32 52					
	+	61	tanh 2πd				
	÷	81	had				
	RCL 1	34 01					
	x	71					
	RCL 3	34 03					
	+	61					
	2	02					
	÷	81					
050	STO 2	33 02					
	RCL 3	34 03					
	-	51					
	h ABS	35 64					
	1	01					
	2 x ² y	32 81					
	GTO E	22 15					

PORTION OF
PROGRAM
NEEDED
FOR METRIC

Program Description

Program Title	100A Linear Wave Theory Wavelength (AOS logic)		
Name	J.R. Weggel	Date	12/80
Address	Coastal Engineering Research Center		
City	Kingman Building	State	Virginia
	Fort Belvoir,	Zip Code	22060

Program Description, Equations, Variables, etc.

This algorithm takes deepwater wavelength as input and using the depth at a given site iterates to obtain wavelength by linear wave theory. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. I, Eq. (2-4), Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings

100A-1

User Instructions

Program Title: 100A Linear Wave Theory Wavelength (AOS logic)

[illegible]

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
000	76	LBL		053	06	06	
001	11	A		054	65	x	
002	42	STD	$T \rightarrow R_7$	055	02	2	
003	07	07		056	65	x	
004	03	3		057	89	π	
005	02	2		058	95	=	
006	93	.		059	42	STD	$2\pi d \rightarrow R_{00}$
007	02	2		060	00	00	
008	42	STD	$g_{ENGLISH} \rightarrow R_6$	061	43	RCL	
009	06	06		062	01	01	
010	76	LBL		063	76	LBL	
011	17	B*		064	19	D*	
012	03	3 *		065	42	STD	$L_{OLD} \rightarrow R_3$
013	07	7 *	"T" PRINT CODE	066	03	03	
014	69	DP *		067	35	1/X	
015	04	04 *		068	65	x	
016	43	RCL		069	43	RCL	
017	07	07		070	00	00	
018	69	DP *		071	95	=	
019	06	06 *	PRINT T	072	42	STD	$2\pi d / L_{OLD} \rightarrow R_4$
020	33	X ²		073	04	04	
021	65	x		074	22	INV	
022	43	RCL	$L_0 = gT^2/2\pi$	075	23	LNx	
023	06	06		076	75	-	
024	55	+		077	48	EXC	
025	02	2		078	04	04	
026	55	+		079	94	+/-	
027	89	π		080	22	INV	
028	95	=		081	23	LNx	
029	42	STD	$L_0 \rightarrow R_{01}$	082	42	STD	
030	01	01		083	05	05	
031	02	2 *		084	95	=	
032	07	7 *	"L ₀ " PRINT CODE	085	55	+	
033	03	3 *		086	53	(	
034	02	2 *		087	43	RCL	
035	69	DP *		088	04	04	
036	04	04 *		089	85	+	
037	43	RCL		090	43	RCL	
038	01	01 *		091	05	05	
039	69	DP *	PRINT L ₀	092	95	=	$\tanh 2\pi d / L_{00}$
040	06	06 *		093	65	x	
041	91	R/S		094	43	RCL	
042	76	LBL		095	01	01	
043	12	B	ENTER d	096	85	+	
044	98	ADV *		097	43	RCL	
045	32	X:T		098	03	03	
046	01	1 *		099	95	=	
047	06	6 *	"d" PRINT CODE	100	55	+	
048	69	DP *		101	02	2	
049	04	04 *		102	95	=	
050	01	1		103	42	STD	$L_{NEW} \rightarrow R_2$
051	32	X:T		104	02	02	
052	69	DP *	PRINT d	105	75	-	
				106	43	RCL	

100A-3

* DELETE IF PRINTER IS NOT AVAILABLE

STEP	KEY ENTRY	KEY CODE	COMMENTS
107	03	03	
108	95	=	
109	50	I×I	
110	22	INV	
111	77	GE	
112	18	C'	
113	43	RCL	
114	02	02	
115	19	D'	
116	76	LBL	
117	18	C'	
118	02	2 *	"L" PRINT CODE
119	07	7 *	
120	69	DP *	
121	04	04 *	
122	43	RCL	
123	02	02	
124	69	DP *	PRINT L
125	06	06 *	L IN DISPLAY
126	91	R/S	
127	76	LBL	
128	16	A'	
129	42	STO	
130	07	07	ROUTINE TO PUT g=9.81
131	09	9	INTO R ₆ FOR
132	93	.	METRIC
133	08	8	CALCULATIONS
134	01	1	
135	42	STO	
136	06	06	
137	03	3 *	DELETE IF
138	00	0 *	ONLY ENGLISH
139	69	DP *	UNITS ARE TO
140	04	04 *	BE PROCESSED
141	69	DP *	
142	05	05 *	
143	17	B'	

Program Description

Program Title	101R Calculation of Wave Parameters from Linear Theory(RPN logic)		
Name	T.L. Walton, Jr.	Date	12/80
Address	Coastal Engineering Research Center		
City	Kingman Building	State	Virginia
	Fort Belvoir,	Zip Code	22060

Program Description, Equations, Variables, etc.

This program calculates the product of the wave number and depth, kd , the ratio of group wave speed to wave celerity, $n = 0.5 (1+2kd/\sinh 2kd)$, the group wave speed, C_g , the shoaling coefficient, K_s , the refraction coefficient, K_r , horizontal orbital velocity, u , and vertical orbital velocity, w .

Program input includes wave period, T , deepwater wave angle, α_0 , deepwater wave height, H_0 , wave phase angle, θ , depth of water, d , at which results are desired, and depth from surface, z , at which velocities are calculated. This program assumes straight and parallel offshore bottom contours for assumption of Snell's law of refraction. Algorithm uses English or metric system of units.

REFERENCES

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. I, Ch. 2, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings This program can also be used for wave input H , T , and α , from transitional water depths (as in the case when wave gage information is provided but the gage is not in deep water). In this instance, some program steps must be deleted as noted in the program listing, and the K_r computed in the program is *not* the refraction coefficient for depth, d , but a *modified* refraction coefficient from the gage site to water depth, d .

101R-1

User Instructions

Program Title: 101R Calculation of Wave Parameters from Linear Theory

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
	TO COMPUTE WAVE PARAMETERS		☐ ☐	
			☐ ☐	
	IF DESIRED TO CALCULATE ORBITAL VELOCITIES U, W AT A SPECIFIED PHASE ANGLE, "θ", INCLUDE THE FOLLOWING STEPS:		☐ ☐	
1	ENTER H ₀ (FT OR M) IN DISPLAY *	H ₀ (FT OR M)	☐ ☐	
2	PRESS STO B, STORING H IN R _B		STO B	
3	ENTER Z (FT OR M) IN DISPLAY	Z (FT OR M)	☐ ☐	
4	PRESS STO B, STORING Z IN R _B		STO B	
5	ENTER θ (DEGREES) IN DISPLAY	θ (DEGREE)	☐ ☐	
6	PRESS STO E, STORING θ IN R _E		STO E	
			☐ ☐	
	IF U AND W ARE NOT DESIRED THE FOREGOING STEPS CAN BE OMITTED		☐ ☐	
			☐ ☐	
7	ENTER WAVE PERIOD T (SEC)	T (SEC)	A	T
8	ENTER DEPTH d (METERS OR FT)	d (FT OR M)	B	2πd
9	ENTER DEEPWATER WAVE ANGLE α ₀ (DEGREES)	α ₀ (DEG)	C	SIN α
10	PRESS E TO COMPUTE WAVE PARAMETERS IN ENGLISH UNITS OR;		E	ENGLISH
	PRESS D FOR METRIC UNITS		D	METRIC
11	READ Kd IN DISPLAY		☐ ☐	Kd
12	PRESS R/S AND READ n		R/S	n
13	PRESS R/S AND READ C _g (FT OR M)		R/S	C _g (FT OR M)
14	PRESS R/S AND READ K _s		R/S	K _s
15	PRESS R/S AND READ K _r		R/S	K _r
16*	PRESS R/S AND READ H (FT OR M) *		R/S	H (FT OR M)
17	PRESS R/S AND READ U (FT/SEC OR M/SEC)		R/S	U (FT/SEC OR M/SEC)
18	PRESS R/S AND READ W (FT/SEC OR M/SEC)		R/S	W (FT/SEC OR M/SEC)
			☐ ☐	
	SEE EXAMPLE, NEXT PAGE		☐ ☐	
			☐ ☐	
	* IF WAVE HEIGHT H AT DEPTH d IS ENTERED, DELETE STEPS WITH ASTERISK *.		☐ ☐	
			☐ ☐	

101R-2

User Instructions

Program Title: 101R Calculation of Wave Parameters from Linear Theory

[illegible]

101R-3

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	F LBL A	31 25 11			=	R1	
	STO 2	33 00	T → R ₂		C/RT	31 54	
	RIS	84			STO A	33 11	$K_s = \sqrt{C_{g0}/C_g} \rightarrow R_A$
	F LBL B	31 25 12		060	RIS	84	K_s IN DISPLAY
	h TI	35 73			RCL 0	34 00	
	X	71			RCL 1	34 01	
	R	02			X	71	
	X	71			RCL 3	34 03	
	STO 1	33 01	2 TI d → R ₁		=	R1	$K_{od} \sin \alpha$
010	RIS	84			RCL 9	34 09	$\sin \alpha$
	F LBL C	31 25 13			=	R1	
	F SIN	31 62	$\sin \alpha_0 \rightarrow R_0$		g X ²	32 54	
	STO 0	33 00		070	I	01	
	RIS	84			=	R1	$\cos^2 \alpha$
	F LBL D	31 25 14			CHS	42	
	9	09			h Yx	35 62	
	.	83			I	01	
	B	08			ENTER	41	
	I	01			RCL 0	34 00	
020	STO D	33 14	g(METRIC) → R _D		g X ²	32 54	
	F GSB 0	31 22 00			=	R1	
	GTO F	22 31 11			X	71	
	F LBL E	31 25 15		080	F Yx	31 54	
	3	03			PV X ¹	31 54	
	2	02			h STI	35 33	$K_r \rightarrow R_1$
	.	83			RIS	84	K_r IN DISPLAY
	2	02			F LBL B	32 25 12	
	STO D	33 14	g(ENGLISH) → R _D		RCL 8	34 08	
	F GSB 0	31 22 00			h RCI #	35 34	
030	GLBL F	32 25 11			X #	71	
	2	02			RCL A #	34 11	
	X	71			X #	71	
	STO A	33 11	$\frac{4 TI d}{L} \rightarrow R_A$		RIS #	84	
	F GSB 1	31 22 01		090	RCL D	34 14	
	h Yx	35 62			X	71	
	RCL A	34 11			RCL 2	34 02	
	X	71			X	71	
	I	01			2	02	
	T	61			=	R1	
040	2	02			RCL 4	34 04	
	=	R1			=	R1	
	STO A	33 11	$n \rightarrow R_A$		RCL 6	34 06	
	RIS	84	n IN DISPLAY		=	R1	
	RCL A	34 04		100	STO 8	33 08	
	X	71			RCL 1	34 01	
	RCL 2	34 02			2	02	
	=	R1			=	R1	
	RIS	84	C_g IN DISPLAY		h TI	35 73	
	h Yx	35 62			=	R1	
050	RCL 2	34 02			RCL B	34 12	
	X	71			+	61	
	RCL D	34 14			2	02	
	X	71			X	71	
	4	04		110	h TI	35 73	
	=	R1			X	71	
	h TI	35 73			RCL 4	34 04	

101R-4

DELETE THESE STEPS IF ENTERED WAVE HEIGHT IS AT DEPTH d

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
	$\div$	81	$\frac{2\pi(2+d)}{L} \rightarrow R_5$		RCL 1	3A 01	$K_d \rightarrow R_9$ $\text{SUB SIN}(\)$
	STO 5	33 05		170	RCL 4	34 04	
	F GSB 2	31 22 02			$\div$	81	
	RCL 8	34 08			STO 9	33 09	
	x	71			RIS	84	
	RCL E	34 15	U IN DISPLAY		h RTN	35 22	$\text{SUB SIN}(\)$
	C CG	31 63			F LBL 1	31 25 01	
120	x	71			STO 7	33 07	
	RIS	84			$\frac{2}{e^x}$	32 52	
	RCL 5	34 05			RCL 7	34 07	
	F GSB 1	31 22 01	W IN DISPLAY		CHS	42	$\text{SUB COSH}(\)$
	RCL 8	34 08		180	$\frac{2}{e^x}$	32 52	
	x	71			-	51	
	RCL E	34 15			2	02	
	C SIN	31 62			$\div$	81	
	x	71	SUB TO CALC. L		h RTN	35 22	
	RIS	84			F LBL 2	31 25 02	
130	C LBL 0	31 25 00			STO 7	33 07	
	RCL 2	34 02			$\frac{2}{e^x}$	32 52	
	$\frac{2}{x^2}$	32 54			RCL 7	34 07	
	RCL D	34 14	$L_0 \rightarrow R_3$		CHS	42	
	x	71		190	$\frac{2}{e^x}$	32 52	
	2	02			+	61	
	$\div$	81			2	02	
	h π	35 13			$\div$	81	
	$\div$	81	$L_{00} \rightarrow R_4$		h RTN	35 22	
	STO 3	33 03					
140	F LBL E d	32 25 14					
	STO A	33 11					
	h y_x	35 62					
	RCL 1	34 01	$\frac{2\pi d}{L_{00}} \rightarrow R_c$	200			
	x	71					
	STO C	33 13					
	F GSB 2	31 22 02					
	STO 6	33 06					
	RCL C	34 13	$\cosh(\frac{2\pi d}{L_{00}}) \rightarrow R_6$				
	F GSB 1	31 22 01					
150	STO 5	33 05					
	RCL 6	34 06					
	$\div$	81					
	RCL 3	34 03	$\sinh(\frac{2\pi d}{L_{00}}) \rightarrow R_5$				
	x	71					
	RCL A	34 11		210			
	$\div$	61					
	2	02					
	$\div$	81	$L_{\text{NEW}} \rightarrow R_4$				
	STO 4	33 04					
160	RCL A	34 11					
	-	51					
	h ABS	35 64					
	1	01		220			
	$\frac{2}{x^2 y}$	32 81					
	STO 5 e	22 31 15					
	RCL A	34 04					
	STO 2 d	22 31 14					
	F LBL E e	32 25 15					

Program Description

Program Title	101A Calculation of Wave Parameters from Linear Theory(AOS logic)		
Name	W.A. Birkemeier	Date	5/81
Address	CERC Field Research Facility		
City	Kitty Hawk,	State	North Carolina Zip Code 27949

Program Description, Equations, Variables, etc.

This program calculates the product of the wave number and depth, kd , the ratio of group wave speed to wave celerity, $n = 0.5 (1+2kd/\sinh 2kd)$, the group wave speed, C_g , the shoaling coefficient, K_s , the refraction coefficient, K_r , horizontal orbital velocity, u , and vertical orbital velocity, w .

Program input includes wave period, T , deepwater wave angle, α_0 , deepwater wave height, H_0 , wave phase angle, θ , depth of water, d , at which results are desired, and depth from surface, z , at which velocities are calculated. This program assumes straight and parallel offshore bottom contours for assumption of Snell's law of refraction. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. I, Ch. 2, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings This program can also be used for wave input H , T , and α , from transitional water depths (as in the case when wave gage information is provided but the gage is not in deep water). In this instance, some program steps must be deleted as noted in the program listing, and the K_r computed in the program is *not* the refraction coefficient for depth, d , but a *modified* refraction coefficient from the gage site to water depth, d .

101A-1

User Instructions

Program Title: 101A Calculation of Wave Parameters from Linear Theory

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
	TO COMPUTE WAVE PARAMETERS		<input type="text"/>	<input type="text"/>	
1	ENTER WAVE PERIOD T (SEC)	T (SEC)	A	<input type="text"/>	T
2	ENTER DEPTH d (ft OR m)	d	B	<input type="text"/>	2nd
3	ENTER DEEPWATER WAVE ANGLE	α_0 (deg)	C	<input type="text"/>	$\sin \alpha_0$
4	PRESS E TO COMPUTE WAVE PARAMETERS (ENGLISH UNITS) OR PRESS D FOR METRIC UNITS		E	<input type="text"/>	
	NOTE: WITH A PRINTER K_d, n, C_g, K_s ARE PRINTED AND LABELED IN ABOUT 20 SEC, OTHERWISE!	K_r	D	<input type="text"/>	
5	READ K_d IN DISPLAY		<input type="text"/>	<input type="text"/>	K_d
6	PRESS R/S AND READ n		R/S	<input type="text"/>	n
7	PRESS R/S AND READ C_g (ft/SEC OR m/SEC)		R/S	<input type="text"/>	C_g
8	PRESS R/S AND READ K_s		R/S	<input type="text"/>	K_s
9	PRESS R/S AND READ K_r		R/S	<input type="text"/>	K_r
	TO REPEAT, ENTER NEW VALUE USING STEPS 1, 2, OR 3 AND STEP 4		<input type="text"/>	<input type="text"/>	
	TO COMPUTE WAVE ORBITAL VELOCITY, AFTER COMPLETING THE ABOVE STEPS,		<input type="text"/>	<input type="text"/>	
A	ENTER DEEPWATER WAVE HEIGHT H_0 (ft OR m) PRESS A'	H_0	2nd	A'	
	NOTE: IF H_1 NOT H_0 IS KNOWN, DELETE PROGRAM STEPS MARKED BY ●.		<input type="text"/>	<input type="text"/>	
	THEN ENTER H INSTEAD OF H_0 .		<input type="text"/>	<input type="text"/>	
B	ENTER DEPTH BELOW STILL WATER (NEGATIVE ft OR m)	z	2nd	B'	
C	COMPUTE AND ENTER THE PHASE ANGLE $\theta = \left(\frac{2\pi x}{L} - \frac{2\pi t}{T} \right)$ IN DEGREES	θ (DEG)	2nd	C'	

101A-2

User Instructions

Program Title: 101A Calculation of Wave Parameters from Linear Theory

[illegible]

101A-3

User Instructions

Program Title: 101A Calculation of Wave Parameters from Linear Theory

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
	EXAMPLE : CALCULATE WAVE PARAMETERS FOR :			
	$T = 8 \text{ sec}$			
	$d = 50 \text{ ft}$			
	$\alpha_0 = 30^\circ$			
	$H_0 = 18 \text{ ft}$			
	$Z = -15 \text{ ft}$			
	$\theta = 60^\circ$			
	ENTER T PRESS A	8 sec	A	8
	ENTER d PRESS B	50 ft	B	314.15
	ENTER α_0 PRESS C	30°	C	0.5
	PRESS E TO COMPUTE		E	
	CALCULATED VALUES ARE PRINTED OR			
	READ $K_d = 1.163$			1.163
	PRESS R/S AND READ $n = 0.729$			0.729
	PRESS R/S AND READ $C_g = 24.625 \text{ ft/sec}$			24.625
	PRESS R/S AND READ $K_s = 0.912$			0.912
	PRESS R/S AND READ $K_r = 0.954$			0.954
	ENTER H_0 PRESS A'	18 ft	2nd A'	223.65
	ENTER Z PRESS B'	-15 ft	2nd B'	-94.25
	ENTER θ PRESS C'	60°	2nd C'	
	CALCULATED VALUES ARE PRINTED OR:			
	READ $H = 16.0 \text{ ft}$, PRESS R/S AND READ $U = 2.944 \text{ ft/sec}$			2.944
	PRESS R/S AND READ $W = 3.426 \text{ ft/sec}$			3.426
	EXAMPLE	8. T		
	PRINTOUT	50. D		
		30. ANGO		
	1.16314388	KD		
	0.729367164	N		
	24.62479667	CG		
	.9123924245	KS		
	.9748438618	KR		
	18. HO			
	-15. Z			
	60. PANG			
	16.00992278	H		
	2.943703553	U		
	3.42578442	W		

101A-4

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
000	76	LBL		054	91	R/S	SIN α_0 IN DISPLAY
001	11	A		055	76	LBL	
002	42	STO	$T \rightarrow R_2$	056	38	SIN	SUBROUTINE TO
003	02	02		057	42	STO	COMPUTE
004	03	3	*	058	07	07	SIN h (x)
005	07	7	*	059	22	INV	
006	69	DP	*	060	23	LNx	
007	04	04	*	061	75	-	
008	43	RCL	*	062	43	RCL	
009	02	02	*	063	07	07	
010	69	DP	*	064	94	+/-	
011	06	06	*	065	22	INV	
012	91	R/S		066	23	LNx	
013	76	LBL		067	95	=	
014	12	B		068	55	÷	
015	42	STO	$d \rightarrow R_1$	069	02	2	
016	01	01		070	95	=	
017	01	1	*	071	92	RTN	
018	06	6	*	072	76	LBL	
019	69	DP	*	073	39	COS	SUBROUTINE TO
020	04	04	*	074	42	STO	COMPUTE
021	43	RCL	*	075	07	07	COS h (x)
022	01	01	*	076	22	INV	
023	69	DP	*	077	23	LNx	
024	06	06	*	078	85	+	
025	65	x		079	43	RCL	
026	89	π		080	07	07	
027	65	x		081	94	+/-	
028	02	2		082	22	INV	
029	95	=		083	23	LNx	
030	42	STO	$2\pi d \rightarrow R_{11}$	084	95	=	
031	11	11		085	55	÷	
032	91	R/S	$2\pi d$ IN DISPLAY	086	02	2	
033	76	LBL		087	95	=	
034	13	C		088	92	RTN	
035	42	STO	$\alpha_0 \rightarrow R_0$	089	76	LBL	
036	00	00		090	14	D	
037	01	1	*	091	09	9	
038	03	3	*	092	93	.	
039	03	3	*	093	08	8	
040	01	1	*	094	01	1	
041	02	2	*	095	42	STO	
042	02	2	*	096	13	13	
043	00	0	*	097	03	3	*
044	01	1	*	098	00	0	*
045	69	DP	*	099	69	DP	*
046	04	04	*	100	04	04	*
047	43	RCL	*	101	69	DP	*
048	00	00	*	102	05	05	*
049	69	DP	*	103	61	GTO	
050	06	06	*	104	43	RCL	
051	38	SIN		105	76	LBL	
052	42	STO	SIN $\alpha_0 \rightarrow R_0$	106	15	E	
053	00	00		107	03	3	

* - DELETE IF PRINTER IS NOT AVAILABLE

101A-5

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
108	02	2	$g = 32.2 \text{ ft/sec}^2$	162	55	+	
109	93	.		163	02	2	
110	02	2		164	95	=	
111	42	STD		165	42	STD	
112	13	13	$\rightarrow R_{13}$	166	04	04	$L_{NEW} \rightarrow R_4$
113	76	LBL		167	75	-	
114	43	RCL		168	43	RCL	
115	98	ADY		169	10	10	
116	01	1		170	95	=	
117	32	X:T		171	50	I×I	ITERATE UNTIL
118	43	RCL	$1 \rightarrow t_{\text{register}}$	172	22	INV	$L_{NEW} - L_{OLD} < t$
119	02	02		173	77	GE	WHERE t IS VALUE
120	33	X ²		174	10	E ¹	IN t REGISTER
121	65	x		175	43	RCL	
122	43	RCL		176	04	04	
123	13	13		177	19	D ¹	
124	55	÷	$L_0 = gT^2/2\pi$	178	76	LBL	
125	02	2		179	10	E ¹	
126	55	÷		180	43	RCL	
127	89	π		181	11	11	
128	95	=		182	55	÷	
129	42	STD	$L_0 \rightarrow R_3$	183	43	RCL	
130	03	03		184	04	04	
131	76	LBL		185	95	=	
132	19	D ¹		186	42	STD	$\frac{2\pi d}{L} = Kd \rightarrow R_4$
133	42	STD	$L_{OLD} \rightarrow R_{10}$	187	09	09	
134	10	10		188	02	2	*
135	35	1/X		189	06	6	*
136	65	x		190	01	1	*
137	43	RCL		191	06	6	*
138	11	11		192	69	DP	*
139	95	=	$\frac{2\pi d}{L_{OLD}} \rightarrow R_{12}$	193	04	04	*
140	42	STD		194	43	RCL	*
141	12	12		195	09	09	*
142	71	SBR		196	69	DP	*
143	39	COS	$\cosh\left(\frac{2\pi d}{L_{OLD}}\right) \rightarrow R_6$	197	06	06	*
144	42	STD		198	65	x	
145	06	06		199	02	2	
146	43	RCL		200	95	=	
147	12	12		201	42	STD	
148	71	SBR		202	10	10	
149	38	SIN		203	71	SBR	
150	42	STD	$\sinh\left(\frac{2\pi d}{L_{OLD}}\right) \rightarrow R_5$	204	38	SIN	
151	05	05		205	35	1/X	
152	55	÷		206	65	x	
153	43	RCL		207	43	RCL	
154	06	06		208	10	10	
155	65	x		209	85	+	
156	43	RCL		210	01	1	
157	03	03		211	95	=	
158	85	+		212	55	÷	
159	43	RCL		213	03	3	*
160	10	10		214	01	1	*
161	95	=		215	69	DP	*

* → DELETE IF PRINTER IS NOT AVAILABLE
 R/S → INSERT IF PRINTER IS NOT AVAILABLE

101A-6

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
216	04	4	*	271	11	11	
217	02	2		272	55	÷	
218	95	=		273	43	RCL	
219	42	STD	$n \rightarrow R_{10}$	274	03	03	
220	10	10		275	55	÷	
221	69	DP	PRINT n	276	43	RCL	
222	06	06		277	09	09	
223	65	x		278	95	=	
224	01	1	*	279	33	X ²	
225	05	5	*	280	75	-	
226	02	2	*	281	01	1	
227	02	2	*	282	95	=	
228	69	DP	*	283	94	+/-	$\cos^2 \alpha$
229	04	04	*	284	35	1/X	
230	43	RCL		285	65	x	
231	04	04		286	53	(	
232	55	÷		287	01	1	
233	43	RCL		288	75	-	
234	02	02		289	43	RCL	
235	95	=		290	00	00	
236	69	DP	* PRINT Cg	291	33	X ²	
R/S → 237	06	06	*	292	95	=	
238	35	1/X		293	34	FX	
239	65	x		294	34	FX	
240	02	2	*	• 295	42	STD	
241	06	6	*	• 296	01	01	
242	03	3	*	297	69	DP	* PRINT K _r
243	06	6	*	298	06	06	*
244	69	DP	*	299	98	ADP	
245	04	04	*	300	91	R/S	
246	43	RCL		301	76	LBL	
247	02	02		302	16	R ¹	REMAINING STEPS REQUIRED IF ORBITAL VELOCITIES ARE DESIRED
248	65	x		303	42	STD	
249	43	RCL		304	08	08	
250	13	13		305	02	2	* H ₀ → R _B
251	55	÷		306	03	3	* "H ₀ " PRINT CODE
252	04	4		• 307	00	0	*
253	55	÷		• 308	01	1	*
254	89	π		309	69	DP	*
255	95	=		310	04	04	*
256	34	FX		311	43	RCL	*
257	42	STD	$K_s = \sqrt{C_g/c_g} \rightarrow R_{10}$	312	08	08	*
258	10	10		• 313	65	x	
259	69	DP	* PRINT K _s	314	69	DP	* PRINT H ₀
260	06	06	*	315	06	06	*
261	02	2	*	• 316	43	RCL	
262	06	6	*	• 317	10	10	
263	03	3	*	• 318	65	x	
264	05	5	*	• 319	43	RCL	
265	69	DP	*	• 320	01	01	
266	04	04	*	• 321	95	=	H = H ₀ K _r K _s
267	43	RCL		• 322	42	STD	→ R ₃
268	00	00		• 323	03	03	
269	65	x		324	65	x	
270	43	RCL		325	43	RCL	

* - DELETE IF PRINTER IS NOT AVAILABLE
R/S - INSERT IF PRINTER IS NOT AVAILABLE
• - DELETE IF H₁ NOT H₀ IS KNOWN

101A-7

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
326	13	13		381	03	3	*
327	65	x		382	69	DP	* "H" PRINT CODE
328	43	RCL		383	04	04	*
329	02	02		384	43	RCL	
330	55	+		385	03	03	
331	02	2		386	69	DP	* PRINT H
332	55	+		387	06	06	*
333	43	RCL		R/S → 388	43	RCL	
334	04	04		389	16	16	
335	55	+		390	85	+	
336	43	RCL		391	43	RCL	
337	06	06		392	11	11	
338	95	=	$\frac{H}{2} \frac{gt}{L} \frac{1}{\cosh(\frac{2\pi d}{L})}$	393	95	=	
339	42	STO	→ R ₈	394	55	+	
340	08	08		395	43	RCL	
341	91	R/S		396	04	04	
342	76	LBL		397	95	=	
343	17	B*		398	42	STO	$\frac{2\pi(z+d)}{L} \rightarrow R_{14}$
344	42	STO	* $\pi \rightarrow R_{16}$	399	14	14	
345	16	16		400	71	SBR	
346	04	4	*	401	39	COS	$\cosh(R_{14})$
347	06	6	* "Z" PRINT CODE	402	65	x	
348	69	DP	*	403	04	4	*
349	04	04	*	404	01	1	* "U" PRINT CODE
350	43	RCL	*	405	69	DP	*
351	16	16	*	406	04	04	*
352	69	DP	*	407	43	RCL	
353	06	06	*	408	08	08	
354	65	x		409	65	x	
355	02	2		410	43	RCL	
356	65	x		411	15	15	
357	89	π		412	39	COS	$\cos G$
358	95	=		413	95	=	
359	42	STO	$2\pi Z \rightarrow R_{16}$	414	69	DP	* PRINT U
360	16	16		R/S → 415	06	06	*
361	91	R/S		416	04	4	*
362	76	LBL		417	03	3	* "W" PRINT CODE
363	18	C*		418	69	DP	*
364	42	STO	$G \rightarrow R_{15}$	419	04	04	*
365	15	15		420	43	RCL	
366	03	3	*	421	14	14	
367	03	3	* "PANG" PRINT CODE	422	71	SBR	$\sinh(R_{14})$
368	01	1	* (PHASE ANGLE)	423	38	SIN	
369	03	3	*	424	65	x	
370	03	3	*	425	43	RCL	
371	01	1	*	426	08	08	
372	02	2	*	427	65	x	
373	02	2	*	428	43	RCL	
374	69	DP	*	429	15	15	$\sin G$
375	04	04	*	430	38	SIN	
376	43	RCL	*	431	95	=	
377	15	15	*	432	69	DP	* PRINT W
378	69	DP	* PRINT G	433	06	06	*
379	06	06	*	434	98	ADV	*
380	02	2	*	435	91	R/S	

* - DELETE IF PRINTER IS UNAVAILABLE
R/S - INSERT IF PRINTER IS UNAVAILABLE
0 - DELETE IF H, NOT H₀ IS KNOWN

101A-8

Program Description

Program Title	102R Linear Wave Approximation to Breaking Wave Height and Breaking Wave Angle (RPN logic)		
Name	T.L. Walton, Jr.	Date	10/80
Address	Coastal Engineering Research Center		
City	Kingman Building Fort Belvoir,	State	Virginia
		Zip Code	22060

Program Description, Equations, Variables, etc.

This program calculates breaking wave height, H_b , and breaking wave angle, α_b , using linear wave theory approximations combined with the shallow-water breaking assumption. Input parameters are wave height, H , wave period, T , wave angle, α , and the water depth, d , where the preceding three variables are measured. An additional input parameter is nearshore beach slope, m . The ratio of the breaking wave height to the water depth at breaking is predicted using the equation

$$\kappa = H_b/d_b = 1.16 \left(\frac{m}{\sqrt{H'_0/L_0}} \right)^{0.22}$$

from Singamsetti and Wind (1980), where d_b is the water depth at breaking, H'_0 the deepwater wave height, and L_0 the deepwater wavelength. This solution requires the assumption of straight and parallel offshore bottom contours for the application of Snell's law of refraction. Input wave parameters H , T , and α can be in any depth of water, d . Algorithm uses English or metric system of units. The development of the equation is derived on the attached solution sheet.

REFERENCES

SINGAMSETTI, S.R., and WIND, H.G., "Characteristics of Shoaling and Breaking Periodic Waves Normally Incident to Plane Beaches of Constant Slope," Report No. M1371, Toegepast Onberzoek Waterstaat, July 1980.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. I, Ch. 2, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings

102R-1

SOLUTION SHEET FOR PROGRAM 102R

Development of the equation:

From conservations of energy

$$\frac{\gamma H^2}{8} C_g \cos \alpha = \frac{\gamma H_i^2}{8} C_{gi} \cos \alpha_i \quad (1)$$

where the subscript i indicates incident wave parameters.

If left hand side of above equation represents conditions at breaking then

$$C_g = C = C_b = \sqrt{gd_b} = \sqrt{gH_b/\kappa} \quad (2)$$

where $\kappa = \frac{H_b}{d_b} \quad (3)$

Now assume $\kappa = 1.16 \left(\frac{m}{\sqrt{H'_0}/L_0} \right)^{0.22} \quad (4)$

where H'_0 is unrefracted deepwater wave height.

Using (1), (2), (3), and (4) it can be found

$$H_b = \left\{ \left(\frac{\kappa}{g} \right)^{1/2} H_i^2 C_{gi} \cos \alpha_i \right\}^{2/5} \quad (5)$$

From Snell's law of refraction

$$\frac{\sin \alpha_b}{C_b} = \frac{\sin \alpha_i}{C_i}$$

therefore,

$$\sin \alpha_b = \left(\frac{\sin \alpha_i}{C_i} \right) \left(\frac{g}{\kappa H_b} \right)^{1/2} \quad (7)$$

User Instructions

Program Title: 102R Linear Approximation to Breaking Wave Height
and Breaking Wave Angle

[illegible]

102R-3

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	FLBLA	31 25 11	$m \rightarrow R_e$		X	71	
	STO E	33 15			RCL A	3A 11	
	R/S	84			+	61	
	FLBL B	31 25 12	$d \rightarrow R_1$	060	2	02	
	STO 1	33 01			$\div$	81	
	h π	35 73			STO 4	33 04	$L_{NEW} \rightarrow R_A$
	X	71			RCL A	3A 11	
	2	02			-	51	
	X	71			h ABS	35 64	
010	STO B	33 12	$2\pi d \rightarrow R_0$		1	01	
	R/S	84			$g \times z \rightarrow Y$	32 81	
	FLBL C	31 25 13	$\alpha \rightarrow R_0$		GTO F c	22 31 13	
	STO 0	33 00			RCL A	3A 04	
	R/S	84		070	GTO fd	22 31 14	
	FLBL D	31 25 14	$H \rightarrow R_0$		FLBL Fc	32 25 13	
	STO 8	33 08			RCL B	3A 12	
	R/S	84			RCL A	3A 04	
	FLBL Fc	32 25 15	$T \rightarrow R_2$		$\div$	81	
	STO 2	33 02			STO 9	33 09	$K_d \rightarrow R_9$
020	g	09			R/S	84	K_d IN DISPLAY
	.	83			2	02	
	8	08			X	71	
	1	01			STO A	33 11	$4\pi d \rightarrow R_A$
	STO D	33 14	$g(\text{METRIC}) \rightarrow R_D$	080	FGSB 1	31 22 01	
	GTO b	22 31 12			h y_x	35 62	
	FLBL E	32 25 15	$T \rightarrow R_2$		RCL A	33 11	
	STO 2	33 02			X	71	
	3	23			1	01	
	2	02			+	61	
030	2	02			2	02	
	2	02			$\div$	81	
	STO D	33 14	$g(\text{ENGLISH}) \rightarrow R_D$		STO 1	33 01	$\eta \rightarrow R_1$
	FLBL Fb	32 25 12			R/S	84	η IN DISPLAY
	RCL 2	3A 02		090	RCL A	3A 04	
	$g \times x^2$	32 54			X	71	
	RCL D	3A 14			RCL 2	3A 02	
	X	71			$\div$	81	
	2	02			STO 4	33 04	$C_g \rightarrow R_4$
	$\div$	81			R/S	84	C_g IN DISPLAY
040	h π	35 73			h y_x	35 62	
	$\div$	81			RCL 2	3A 02	
	STO 3	33 03	$L_0 = \frac{gT^2}{2\pi} \rightarrow R_3$		X	71	
	FLBL Fd	32 25 14	$L_{old} \rightarrow R_A$		RCL D	3A 14	
	STO A	33 11		100	X	71	
	h = y_x	35 62			4	04	
	RCL B	3A 12			$\div$	81	
	X	71			h π	35 73	
	STO C	33 13	$2\pi d \rightarrow R_c$		$\div$	81	
	FGSB 2	31 22 02	$\cosh(R_c) \rightarrow R_6$		F $\sqrt{x}$	31 54	
050	STO 6	33 06			STO A	33 11	$K_s = \sqrt{\frac{C_{g0}}{C_g}} \rightarrow R_A$
	RCL C	3A 13			R/S	84	K_s IN C_g DISPLAY
	FGSB 1	31 22 01			RCL B	3A 08	
	STO 5	33 05	$\sinh(R_c) \rightarrow R_5$		RCL A	3A 11	
	RCL 6	3A 06		110	$\div$	81	
	$\div$	81			R/S	84	
	RCL 3	3A 03			RCL 3	3A 03	$H'_0 = H/K_s$ H'_0 IN DISPLAY

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
	$\div$	81			FLBL2	31 25 02	
	FVX	31 54		170	STO 7	33 07	
	RCL E	34 15			$g e^x$	32 52	
	$\div$	81			RCL 7	34 07	
	$h y^x$	35 63			CHS	42	
	$\cdot$	83			$g e^x$	32 52	
	2	02			+	61	
120	2	02			2	02	
	$h y^x$	35 63			$\div$	81	
	1	01			$h RTN$	35 22	
	$\cdot$	83					
	1	01					
	6	06					
	$\times$	71					
	RCL D	34 14					
	$\div$	81					
	STO 6	33 06	$K = \frac{1.14}{g} \left(\frac{m}{\sqrt{H_0/L_0}} \right)^{0.22}$				
130	RCL B	34 08	$\rightarrow R_6$				
	$g x^2$	32 54					
	RCL 4	34 04					
	$\times$	71					
	RCL C	34 00					
	F COS	31 63					
	$\times$	71					
	$\cdot$	83					
	4	04					
	$h y^x$	35 63					
140	RCL 6	34 06					
	$\cdot$	83					
	2	02					
	$h y^x$	35 63					
	$\times$	71					
	RIS	84					
	RCL 6	34 06	$\frac{K}{g}^{1/5} (H^2 C_g \cos \alpha)^{3/5} = H_b$				
	$h y^x$	35 62	IN DISPLAY				
	$\times$	71					
	FVX	31 54					
150	RCL 0	34 00					
	F SIN	31 62					
	$\times$	71					
	RCL 4	34 04					
	$\div$	81	$\frac{\sin \alpha}{C} \left(\frac{g}{K} H_b \right)^{1/2} =$				
	RCL 1	34 01	$\sin \alpha_b$				
	$\times$	71					
	$g \sin^{-1}$	32 62					
	RIS	84	α_b IN DISPLAY				
	FLBL 1	31 25 01					
160	STO 7	33 07					
	$g e^x$	32 52					
	RCL 7	34 07					
	CHS	42					
	$g e^x$	32 52					
	$\cdot$	51					
	2	02					
	$\div$	81					
	$h RTN$	35 22					

SUBROUTINE
COSH ()

Program Description

Program Title	102A Linear Wave Approximation to Breaking Wave Height and Breaking Wave Angle (AOS logic)		
Name	W.A. Birkemeier	Date	5/81
Address	CERC Field Research Facility		
City	Kitty Hawk,	State	North Carolina Zip Code 27949

Program Description, Equations, Variables, etc.

This program calculates breaking wave height, H_b , and breaking wave angle, α_b , using linear wave theory approximations combined with the shallow-water breaking assumption. Input parameters are wave height, H , wave period, T , wave angle, α , and the water depth, d , where the preceding three variables are measured. An additional input parameter is nearshore beach slope, m . The ratio of the breaking wave height to the water depth at breaking is predicted using the equation

$$\kappa = H_b/d_b = 1.16 \left(\frac{m}{\sqrt{H'_0/L_0}} \right)^{0.22}$$

from Singamsetti and Wind (1980), where d_b is the water depth at breaking, H'_0 the deepwater wave height, and L_0 the deepwater wavelength. This solution requires the assumption of straight and parallel offshore bottom contours for the application of Snell's law of refraction. Input wave parameters H , T , and α can be in any depth of water, d . Algorithm uses English or metric system of units. The development of the equation is derived on the solution sheet included with program 102R.

REFERENCES

SINGAMSETTI, S.R., and WIND, H.G., "Characteristics of Shoaling and Breaking Periodic Waves Normally Incident to Plane Beaches on Constant Slope," Report No. M1371, Toegepast Onberzoek Waterstaat, July 1980.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. I, Ch. 2, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings

102A-1

Program Title: 102A Linear Wave Approximation to Breaking Wave Height
and Breaking Wave Angle

102A-2

Program Title: 102A Linear Wave Approximation to Breaking Wave Height
and Breaking Wave Angle

102A-3

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
000	76	LBL		054	02	2 *	"H" PRINT CODE
001	11	A		055	03	3 *	
002	42	STD	$M \rightarrow R_{14}$	056	69	DP *	
003	14	14		057	04	04 *	
004	03	3 *	"M" PRINT CODE	058	43	RCL *	
005	00	0 *		059	08	08 *	
006	69	DP *		060	69	DP *	PRINT H
007	04	04 *		061	06	06 *	
008	43	RCL *		062	91	R/S	
009	14	14 *		063	76	LBL	SUBROUTINE TO COMPUTE
010	69	DP *	PRINT M	064	38	SIN	
011	06	06 *		065	42	STD	
012	91	R/S		066	07	07	$\sinh(x)$
013	76	LBL		067	22	INV	
014	12	B		068	23	LNx	
015	42	STD	$d \rightarrow R_1$	069	75	-	
016	01	01		070	43	RCL	
017	01	1 *	"D" PRINT CODE	071	07	07	
018	06	6 *		072	94	+/-	
019	69	DP *		073	22	INV	
020	04	04 *		074	23	LNx	
021	43	RCL *		075	95	=	
022	01	01 *		076	55	÷	
023	69	DP *	PRINT d	077	02	2	
024	06	06 *		078	95	=	
025	65	x		079	92	RTN	SUBROUTINE TO COMPUTE $\cosh(x)$
026	89	x		080	76	LBL	
027	65	x		081	39	COS	
028	02	2		082	42	STD	
029	95	=		083	07	07	
030	42	STD	$2\pi d \rightarrow R_{11}$	084	22	INV	
031	11	11		085	23	LNx	
032	91	R/S		086	85	+	
033	76	LBL		087	43	RCL	
034	13	C		088	07	07	
035	42	STD	$\omega \rightarrow R_0$	089	94	+/-	
036	00	00		090	22	INV	
037	01	1 *		091	23	LNx	
038	03	3 *	"ANG" PRINT CODE	092	95	=	
039	03	3 *		093	55	÷	
040	01	1 *		094	02	2	
041	02	2 *		095	95	=	
042	02	2 *		096	92	RTN	E' ALLOWS METRIC DATA ENTRY
043	69	DP *		097	76	LBL	
044	04	04 *		098	10	E'	
045	43	RCL *		099	42	STD	
046	00	00 *		100	02	02	$T \rightarrow R_2$
047	69	DP *		101	09	9	
048	06	06 *		102	93	.	$g = 9.81$
049	91	R/S		103	08	8	
050	76	LBL		104	01	1	
051	14	D	$H \rightarrow R_8$	105	42	STD	$g \rightarrow R_{13}$
052	42	STD		106	13	13	
053	08	08		107	03	3 *	

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STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
108	00 0	*	"M" PRINT CODE	162	43 RCL		
109	69 DP	*		163	12 12		
110	04 04	*		164	71 SBR		
111	69 DP	*		165	38 SIN		$\sinh(\frac{2\pi d}{L_{OLD}}) \rightarrow R_5$
112	05 05	*		166	42 STO		
113	17 B'			167	05 05		
114	76 LBL			168	55 +		
115	15 E		"E" ALLOWS	169	43 RCL		
116	42 STO		ENGLISH UNITS	170	06 06		
117	02 02		$T \rightarrow R_2$	171	65 X		
118	03 3		$g = 32.2 \text{ ft/sec}^2$	172	43 RCL		
119	02 2			173	03 03		
120	93 .			174	85 +		
121	02 2			175	43 RCL		
122	42 STO			176	10 10		
123	13 13		$\rightarrow R_{13}$	177	95 =		
124	76 LBL			178	55 +		
125	17 B'			179	02 2		
126	01 1		$1 \rightarrow t$ REGISTER	180	95 =		
127	32 X/T			181	42 STO		$L_{NEW} \rightarrow R_4$
128	03 3	*	"T" PRINT CODE	182	04 04		
129	07 7	*		183	75 -		
130	69 DP	*		184	43 RCL		
131	04 04	*		185	10 10		
132	43 RCL			186	95 =		
133	02 02			187	50 I×I		ITERATE UNTIL
134	69 DP	*		188	22 INV		$L_{NEW} - L_{OLD} < t$
135	06 06	*	PRINT T	189	77 GE		WHERE t IS VALUE
136	33 X ²			190	18 C'		IN t register
137	65 X			191	43 RCL		
138	43 RCL			192	04 04		
139	13 13			193	19 D'		
140	55 +			194	76 LBL		
141	02 2			195	18 C'		
142	55 +			196	43 RCL		
143	89 π			197	11 11		
144	95 =		$L_0 = gT^2/2\pi$	198	55 +		
145	42 STO			199	02 2	*	
146	03 03		$\rightarrow R_3$	200	06 6	*	"KD" PRINT CODE
147	76 LBL			201	01 1	*	
148	19 D'			202	06 6	*	
149	42 STO			203	69 DP	*	
150	10 10		$L_{OLD} \rightarrow R_{10}$	204	04 04	*	
151	35 1/X			205	43 RCL		
152	65 X			206	04 04		
153	43 RCL			207	95 =		
154	11 11			208	42 STO		$\frac{2\pi d}{L} = K_d \rightarrow R_9$
155	95 =			209	09 09		
156	42 STO		$\frac{2\pi d}{L_{OLD}} \rightarrow R_{12}$	210	69 DP	*	
157	12 12			211	06 06	*	PRINT Kd
158	71 SBR			212	65 X		
159	39 COS		$\cosh(\frac{2\pi d}{L_{OLD}}) \rightarrow R_6$	213	02 2		
160	42 STO			214	95 =		
161	06 06			215	42 STO		

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STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
216	10	E'	$\frac{4\pi d}{L} \rightarrow R_{10}$	270	89	n	
217	71	SBR		271	95	=	
218	38	SIN		272	34	FX	
219	35	1/X		273	42	STD	
220	65	x		274	10	10	$K_s = \sqrt{\frac{C g_0}{C_g}} \rightarrow R_{10}$
221	43	RCL		275	69	DP	*
222	10	10		R/S $\rightarrow$ 276	06	06	*
223	85	+		SEE BELOW $\rightarrow$ 277	02	2	*
224	01	1			278	03	*
225	95	=			279	00	*
226	55	÷			280	01	*
227	03	3	*		281	06	*
228	01	1	*		282	05	*
229	69	DP	* "N" PRINT CODE		283	69	DP
230	04	04	*		284	04	04
231	02	2	*		285	43	RCL
232	95	=			286	08	08
233	42	STD			287	55	÷
234	01	01	n $\rightarrow R_1$		288	43	RCL
235	69	DP	*		289	10	10
236	06	06	* PRINT n		290	95	=
237	65	x	*		291	69	DP
238	01	1	*	R/S $\rightarrow$ 292	06	06	*
239	05	5	*	SEE BELOW $\rightarrow$ 293	55	÷	*
240	02	2	*		294	43	RCL
241	02	2	*		295	03	03
242	69	DP	* "CG" PRINT CODE		296	95	=
243	04	04	*		297	34	FX
244	43	RCL			298	55	÷
245	04	04			299	43	RCL
246	55	÷			300	14	14
247	43	RCL			301	95	=
248	02	02			302	35	1/X
249	95	=			303	45	YX
250	42	STD			304	93	.
251	04	04	CG $\rightarrow R_4$		305	02	2
252	69	DP	*		306	02	2
253	06	06	* PRINT Cg		307	65	x
254	35	1/X	*		308	01	1
255	65	x	*		309	93	.
256	02	2	*		310	01	1
257	06	6	*		311	06	6
258	03	3	* "Ks" PRINT CODE		312	55	÷
259	06	6	*		313	43	RCL
260	69	DP	*		314	13	13
261	04	04	*		315	95	=
262	43	RCL			316	42	STD
263	02	02			317	06	06
264	65	x			318	43	RCL
265	43	RCL			319	08	08
266	13	13			320	33	X ²
267	55	÷			321	65	x
268	04	4			322	43	RCL
269	55	÷			323	04	04

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STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
324	65	X		378	98	ADV	
325	43	RCL		379	91	R/S	
326	00	00					
327	39	COS					
328	95	=					
329	45	YX					
330	93	.					
331	04	4	$(H^2 C_g \cos \alpha)^{2/5}$				
332	65	X					
333	02	2	*				
334	03	3	*	180			
335	01	1	*				
336	04	4	* 'HB' PRINT CODE				
337	69	OP	*				
338	04	04	*				
339	43	RCL					
340	06	06					
341	45	YX					
342	93	.					
343	02	2	$(\frac{K}{g})^2 (H^2 C_g \cos \alpha)^{2/5}$				
344	95	=		190			
345	69	OP	* PRINT H_b				
346	06	06	*				
R/S SEE BELOW → 347	65	X					
348	43	RCL					
349	06	06					
350	35	1/X					
351	95	=					
352	34	FX					
353	65	X					
354	43	RCL		200			
355	00	00					
356	38	SIN					
357	55	÷					
358	01	1	*				
359	03	3	*				
360	03	3	*				
361	01	1	* "ANGB" PRINT CODE				
362	02	2	*				
363	02	2	*	210			
364	01	1	*				
365	04	4	*				
366	69	OP	*				
367	04	04	*				
368	43	RCL					
369	04	04					
370	65	X					
371	43	RCL					
372	01	01					
373	95	=	$\sin \alpha_b = \frac{\sin \alpha}{C_i} (\frac{g}{K} H_b)^{1/2}$	220			
374	22	INV					
375	38	SIN					
376	69	OP	* PRINT α_b				
377	06	06	*				

102A-7

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Program Description

Program Title	103R Shallow-Water Wave Forecasting Equations (RPN logic)		
Name	T.L. Walton, Jr.	Date	10/80
Address	Coastal Engineering Research Center		
City	Kingman Building Fort Belvoir,	State	Virginia
		Zip Code	22060

Program Description, Equations, Variables, etc.

This algorithm computes the wave height, H , wave period, T , and minimum duration, t , from input values of the water depth, d , fetch length, F , and adjusted windspeed, U_A , using equations (1), (2), and (3) of CETN-I-6. Equations (1) and (2) are for constant water depth and unlimited wind duration and have been revised from equations (3-25) and (3-26) of the Shore Protection Manual. Wave height and period in this algorithm are significant wave height and period. Algorithm uses English or metric system of units.

REFERENCES

- U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vols. I, II, and III, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977, 1,262 pp.
- U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, "Method for Determining Adjusted Windspeed, U_A , for Wave Forecasting," CETN-I-5, Fort Belvoir, Va., 1981.
- U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, "Revised Method for Wave Forecasting in Shallow Water," CETN-I-6, Fort Belvoir, Va., 1981.
- U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, "Revised Method for Wave Forecasting in Deep Water," CETN-I-7, Fort Belvoir, Va., 1981.

Operating Limits and Warnings

103R-1

User Instructions

Program Title: 103R Shallow Water Wave Forecasting Equations

[illegible]

103R-2

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	F LBL A	31 25 11	$U_A \rightarrow R_3$		RCL 8	3A 08	$\frac{2F}{U_A^2} \rightarrow R_1$
	STO 3	33 02			RCL 1	3A 01	
	RIS	8A			X	71	
	F LBL B	31 25 12		000	RCL 5	3A 05	
	STO 5	33 05			X	71	
	RIS	8A	$F \rightarrow R_5$		STO 1	33 01	$\frac{2F}{U_A^2} \rightarrow R_1$
	F LBL C	31 25 13	$d \rightarrow R_6$		RCL 0	3A 00	
	STO 6	33 06			.	83	
	RIS	8A			1	01	
	F LBL E	31 25 15			5	05	
010	3	03	$g(\text{ENGLISH}) \rightarrow R_9$		h y^A	35 63	$\tanh \left[.53 \left(\frac{2d}{U_A^2} \right)^{.75} \right] \rightarrow R_1$
	2	02			.	83	
	2	83		070	5	05	
	2	02			3	03	
	STO 9	33 09			X	71	
	1	01	CONVERSION FACTOR $\rightarrow R_7$		F GSB 1	31 22 01	$\tanh \left[.00565 \left(\frac{2F}{U_A} \right)^5 \right] \rightarrow R_1$
	.	83			STO 4	33 04	
	4	04			RCL 1	3A 01	
	7	07			F V X	31 54	
020	STO 7	33 01			.	83	
	5	05	CONVERSION FACTOR $\rightarrow R_1$		0	00	$\tanh \left[.00565 \left(\frac{2F}{U_A} \right)^5 \right] \rightarrow R_1$
	2	02			0	00	
	8	08			5	05	
	0	00		080	6	06	
	STO 1	33 01			5	05	
	GTO Fd	22 31 14	$g(\text{METRIC}) \rightarrow R_9$		X	71	$\tanh \left[.00565 \left(\frac{2F}{U_A} \right)^5 \right] \rightarrow R_1$
	g LBL Fe	32 25 15			RCL 4	3A 04	
	9	09			÷	81	
	.	83			F GSB 1	31 22 01	
030	8	08			RCL 4	3A 04	
	1	01	CONVERSION FACTOR $\rightarrow R_7$		X	71	$H \text{ IN DISPLAY}$
	STO 9	33 09			.	83	
	.	83		090	2	02	
	2	02			8	08	
	7	07			3	03	
	7	07	CONVERSION FACTOR $\rightarrow R_1$		X	71	$\tanh \left[.833 \left(\frac{2d}{U_A^2} \right)^{.375} \right] \rightarrow R_1$
	8	08			RCL 8	3A 08	
	STO 7	33 01			÷	81	
	1	01			RIS	8A	
040	0	00			RCL 0	3A 00	
	0	00	CONVERSION FACTOR $\rightarrow R_1$		.	83	$\tanh \left[.833 \left(\frac{2d}{U_A^2} \right)^{.375} \right] \rightarrow R_1$
	0	00			3	03	
	STO 1	33 01			7	07	
	g LBL Fd	32 25 14		100	5	05	
	RCL 3	3A 03			h y^A	35 63	$\tanh \left[.833 \left(\frac{2d}{U_A^2} \right)^{.375} \right] \rightarrow R_1$
	RCL 1	3A 01	$U_A \rightarrow R_7 \text{ CONVERTED}$		.	83	
	X	71			8	08	
	STO 7	33 01			3	03	
	RCL 9	3A 09			3	03	
050	RCL 7	3A 07	$\frac{8}{U_A^2} \rightarrow R_8$		X	71	$\tanh \left[.833 \left(\frac{2d}{U_A^2} \right)^{.375} \right] \rightarrow R_1$
	g X^2	32 52			F GSB 1	31 22 01	
	÷	81			STO 4	33 04	
	STO 8	33 08			RCL 1	3A 01	
	RCL 6	3A 06		110	.	83	
	X	71	$\frac{8d}{U_A^2} \rightarrow R_0$		3	03	$\tanh \left[.833 \left(\frac{2d}{U_A^2} \right)^{.375} \right] \rightarrow R_1$
	STO 0	33 00			3	03	

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
	3	03			RCL 2	34 02	
	h y ⁺	35 63		170	CHS	42	
	.	03			g e ⁺	32 52	
	0	00			+	61	
	3	03			÷	81	
	1	01			h RTN	35 22	
	9	09					
120	x	71					
	RCL 4	34 04					
	÷	81					
	F GSB 1	31 22 01	$\tanh \left[\frac{.0379 \left(\frac{g}{\omega^2} \right) \cdot 333}{R_4} \right]$	180			
	RCL 4	34 04					
	x	71					
	7	07					
	.	03					
	5	05					
	4	04					
130	x	71					
	RCL 8	34 08					
	÷	81					
	RCL 7	34 07					
	÷	81		190			
	RIS	84	T IN DISPLAY				
	RCL 9	34 09					
	x	71					
	RCL 7	34 07					
	÷	81					
140	2	02					
	.	03					
	3	03					
	3	03					
	3	03		200			
	h y ⁺	35 63					
	5	05					
	3	03					
	7	07					
	x	71					
150	RCL 7	34 07					
	x	71					
	RCL 9	34 09					
	÷	81	t (SECONDS)	210			
	3	03					
	6	06					
	0	00					
	0	00					
	÷	81					
	RIS	84	t (HRS) IN DISPLAY				
160	F LBL 1	31 25 01					
	STO 2	33 02					
	g e ⁺	32 52					
	RCL 2	34 02	SUBROUTINE				
	CHS	42		220			
	g e ⁺	32 52					
	-	51					
	RCL 2	34 02	tanh ()				
	g e ⁺	32 52					

103R-4

Program Description

Program Title	103A Shallow-Water Wave Forecasting Equations (AOS logic)		
Name	W.A. Birkemeier	Date	5/81
Address	CERC Field Research Facility		
City	Kitty Hawk,	State	North Carolina Zip Code 27949

Program Description, Equations, Variables, etc.

This algorithm computes the wave height, H , wave period, T , and minimum duration, t , from input values of the water depth, d , fetch length, F , and adjusted windspeed, U_A , using equations (1), (2), and (3) of CETN-I-6. Equations (1) and (2) are for constant water depth and unlimited wind duration and have been revised from equations (3-25) and (3-26) of the Shore Protection Manual. Wave height and period in this algorithm are significant wave height and period. Algorithm uses English or metric system of units.

REFERENCES

- U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vols. I, II, and III, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977, 1,262 pp.
- U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, "Method for Determining Adjusted Windspeed, U_A , for Wave Forecasting," CETN-I-5, Fort Belvoir, Va., 1981.
- U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, "Revised Method for Wave Forecasting in Shallow Water," CETN-I-6, Fort Belvoir, Va., 1981.
- U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, "Revised Method for Wave Forecasting in Deep Water," CETN-I-7, Fort Belvoir, Va., 1981.

Operating Limits and Warnings

103A-1

User Instructions

Program Title: 103A Shallow-Water Wave Forecasting Equations

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	ENTER ADJUSTED WIND SPEED (U_A) IN EITHER MPH OR KPH	U_A	<input type="text"/> <input type="text"/>	U_A
2	ENTER FETCH LENGTH (F) IN EITHER MILES OR KILOMETERS	F	<input type="text"/> <input type="text"/>	F
3	ENTER DEPTH (d) IN FEET OR METERS	d	<input type="text"/> <input type="text"/>	d
4	TO COMPUTE H, T, AND t PRESS E FOR ENGLISH UNITS PRESS E' FOR METRIC UNITS WITH PRINTER, H, T, AND t ARE AUTOMATICALLY PRINTED AND LABELED OTHERWISE:		<input type="text"/> <input type="text"/>	
5	READ H IN DISPLAY (ft or m)		<input type="text"/> <input type="text"/>	H (ft or m)
6	PRESS R/S AND READ T IN DISPLAY		<input type="text"/> <input type="text"/>	T (SEC)
7	PRESS R/S AND READ THE MINIMUM DURATION t IN HOURS		<input type="text"/> <input type="text"/>	t (hrs)
	EXAMPLE: COMPUTE SIGNIFICANT WAVE HEIGHT AND PERIOD FOR THE FOLLOWING CONDITIONS $U_A = 40$ mph $F = 300$ m. $d = 20$ ft.		<input type="text"/> <input type="text"/>	
	ENTER $U_A = 40$ PRESS A	40 mph	<input type="text"/> <input type="text"/>	40
	ENTER $F = 300$ PRESS B	300 mi	<input type="text"/> <input type="text"/>	300
	ENTER $d = 20$ PRESS C	20 ft	<input type="text"/> <input type="text"/>	20
	PRESS E AND READ $H = 4.53$ ft		<input type="text"/> <input type="text"/>	4.53 ft
	PRESS R/S AND READ $T = 5.60$ SEC		<input type="text"/> <input type="text"/>	5.60 SEC
	PRESS R/S AND READ $t = 3.73$ HRS		<input type="text"/> <input type="text"/>	3.73 hrs
	PRINTOUT OF EXAMPLE		<input type="text"/> <input type="text"/>	
	40. U_A _____		<input type="text"/> <input type="text"/>	
	300. F _____		<input type="text"/> <input type="text"/>	
	20. d _____		<input type="text"/> <input type="text"/>	
	4.531271188 H _____		<input type="text"/> <input type="text"/>	
	5.608173088 T _____		<input type="text"/> <input type="text"/>	
	3.726684287 HRS _____		<input type="text"/> <input type="text"/>	

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STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
000	76	LBL		054	07	07	
001	11	H		055	05	5	
002	42	STD		056	02	2	TO CONVERT F
003	10	10	$U_A \rightarrow R_{10}$	057	08	8	TO FEET (MULTIPLY
004	04	4 *		058	00	0	BY 5280)
005	01	1 *	"U _A " PRINT CODE	059	42	STD	$\rightarrow 01$
006	01	1 *		060	01	01	
007	03	3 *		061	19	D'	
008	69	DP *		062	76	LBL	LBL E SELECTS
009	04	04 *		063	10	E'	METRIC UNITS
010	43	RCL *		064	09	9	
011	10	10 *		065	93	.	
012	69	DP *	PRINT U _A	066	08	8	$g = 9.81$
013	06	06 *		067	01	1	
014	91	R/S		068	42	STD	$g \rightarrow R_9$
015	76	LBL		069	09	09	
016	12	B		070	93	.	CONVERT U _A TO
017	42	STD	$F \rightarrow R_5$	071	02	2	M/SEC MULTIPLY
018	05	05		072	07	7	Kph BY 0.2778
019	02	2 *	"F" PRINT CODE	073	07	7 *	
020	01	1 *		074	08	8	
021	69	DP *		075	42	STD	$\rightarrow R_7$
022	04	04 *		076	07	07	
023	43	RCL *		077	01	1	CONVERT F TO
024	05	05 *		078	00	0	METERS MULTIPLY
025	69	DP *	PRINT F	079	00	0	Km. BY 1000
026	06	06 *		080	00	0	
027	91	R/S		081	42	STD	$\rightarrow R_{01}$
028	76	LBL		082	01	01	
029	13	C		083	03	3 *	
030	42	STD	$d \rightarrow R_6$	084	00	0 *	"M" PRINT CODE
031	06	06		085	69	DP *	
032	01	1 *	"d" PRINT CODE	086	04	04 *	
033	06	6 *		087	69	DP *	PRINT "M" TO
034	69	DP *		088	05	05 *	INDICATE METRIC
035	04	04 *		089	76	LBL	
036	43	RCL *		090	19	D'	
037	06	06 *		091	43	RCL	CONVERT U _A
038	69	DP *	PRINT d	092	10	10	STORE IN R ₇
039	06	06 *		093	49	PRD	
040	91	R/S		094	07	07	
041	76	LBL	LBL E - SELECTS	095	43	RCL	
042	15	E	ENGLISH UNITS	096	09	09	
043	03	3		097	55	÷	
044	02	2	$g = 32.2 \text{ ft/sec}^2$	098	43	RCL	
045	93	.		099	07	07	
046	02	2		100	33	%	
047	42	STD	$g \rightarrow R_9$	101	95	=	
048	09	09		102	42	STD	$g/U_A^2 \rightarrow R_8$
049	01	1	TO CONVERT U _A	103	08	08	
050	93	.	TO ft/SEC	104	49	PRD	
051	04	4	(MULTIPLY BY 1.47)	105	01	01	
052	07	7		106	65	×	
053	42	STD	$1.47 \rightarrow R_7$	107	43	RCL	

103A-3

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
108	06	06		162	95	=	
109	95	=		163	69	OP *	PRINT H
110	42	STD	$dg/U_A^2 \rightarrow R_0$	164	06	06 *	
111	00	00		165	03	3 *	'T' PRINT CODE
112	43	RCL		166	07	7 *	
113	05	05		167	69	OP *	
114	49	PRD	$Fg/U^2 \rightarrow R_1$	168	04	04 *	
115	01	01		169	43	RCL	
116	02	2 *	'H' PRINT CODE	170	00	00	
117	03	3 *		171	45	YX	
118	69	OP *		172	93	.	
119	04	04 *		173	03	3	
120	43	RCL		174	07	7	
121	00	00		175	05	5	
122	45	YX		176	65	X	
123	93	.		177	93	.	
124	07	7		178	08	8	
125	05	5		179	03	3	
126	65	X		180	03	3	
127	93	.		181	95	=	
128	05	5		182	71	SBR	$\tanh\left[833\left(\frac{dg}{U_A^2}\right)^{.375}\right]$
129	03	3		183	30	TAN	$\rightarrow R_4$
130	95	=		184	42	STD	
131	71	SBR		185	04	04	
132	30	TAN	$\tanh\left[53\left(\frac{Fg}{U_A^2}\right)^{.75}\right]$	186	43	RCL	
133	42	STD		187	01	01	
134	04	04		188	45	YX	
135	43	RCL	$\rightarrow R_4$	189	93	.	
136	01	01		190	03	3	
137	34	FX		191	03	3	
138	65	X		192	03	3	
139	93	.		193	65	X	
140	00	0		194	93	.	
141	00	0		195	00	0	
142	05	5		196	03	3	
143	06	6		197	07	7	
144	05	5		198	09	9	
145	55	+		199	55	+	
146	43	RCL		200	43	RCL	
147	04	04		201	04	04	
148	95	=		202	95	=	
149	71	SBR	$\tanh\left[\frac{.00565\left(\frac{Fg}{U_A^2}\right)^5}{R_4}\right]$	203	71	SBR	$\tanh\left[\frac{.0379\left(\frac{Fg}{U_A^2}\right)^{.333}}{R_4}\right]$
150	30	TAN		204	30	TAN	
151	65	X		205	65	X	
152	43	RCL		206	43	RCL	
153	04	04		207	04	04	
154	65	X		208	65	X	
155	93	.		209	07	7	
156	02	2		210	93	.	
157	08	8		211	05	5	
158	03	3		212	04	4	
159	55	+		213	55	+	
160	43	RCL		214	43	RCL	
161	08	08		215	08	08	

103A-4

* DELETE IF PRINTER IS UNAVAILABLE
R/S-INSEPT IF PRINTER IS UNAVAILABLE

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
	216	55 =		270	48 END		
	217	43 RCL		271	02 02		
	218	07 07		272	94 +/-		
	219	95 =		273	22 INV		
	220	69 DP *	PRINT T	274	23 LNX		
R/S →	221	06 06 *		275	42 STD		
	222	65 X		276	03 03		
	223	43 RCL		277	95 =		
	224	09 09		278	55 +		
	225	55 +		279	53 (		
	226	02 2 *		280	43 RCL		
	227	03 3 *	"HRS" PRINT CODE	281	02 02		
	228	03 3 *		282	85 +		
	229	05 5 *		283	43 RCL		
	230	03 3 *		284	03 03		
	231	06 6 *		285	95 =		
	232	69 DP *		286	92 RTN		
	233	04 04 *					
	234	43 RCL					
	235	07 07					
	236	95 =					
	237	45 YX					
	238	53 (					
	239	07 7					
	240	55 +					
	241	03 3					
	242	54)					
	243	65 X					
	244	05 5					
	245	03 3					
	246	07 7					
	247	65 X					
	248	43 RCL					
	249	07 07					
	250	55 +					
	251	43 RCL	$t = \frac{U_A}{g} 539 \left(\frac{T_0}{U_A} \right)^{2/3}$				
	252	09 09					
	253	55 +					
	254	03 3	CONVERT SECONDS				
	255	06 6	TO HOURS				
	256	00 0					
	257	00 0					
	258	95 =					
	259	69 DP *	PRINT MINIMUM				
	260	06 06 *	DURATION t				
	261	98 ADV *					
	262	91 R/S					
	263	76 LBL	SUBROUTINE TO				
	264	30 TAN	COMPUTE TAN H(X)				
	265	42 STD					
	266	02 02					
	267	22 INV					
	268	23 LNX					
	269	75 -					

*- DELETE IF A PRINTER IS UNAVAILABLE
R/S - INSERT IF PRINTER IS UNAVAILABLE

103A-5

Program Description

Program Title	104R Depth-Limited Design Breaking Wave Height at Structure (RPN logic)		
Name	T.L. Walton, Jr.	Date	10/80
Address	Coastal Engineering Research Center		
City	Kingman Building	Zip Code	22060
	Fort Belvoir,	Virginia	
Program Description, Equations, Variables, etc.			
<p>This algorithm computes the depth-limited breaking wave height at a structure for design purposes. It can be used in lieu of Figure 7-4 of the Shore Protection Manual. The equation for the curves in Figure 7-4 is not given in the SPM but can be found by simultaneous solution of SPM equations (2-91), (2-92), (2-93), (7-3), and (7-4). Input is wave period, T, and water depth at the structure toe, d_s. The development of the equation is derived on the attached solution sheet. Algorithm uses English or metric system of units.</p>			
REFERENCE			
<p>U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, <i>Shore Protection Manual</i>, 3d ed., Vols. I and II, Chs. 2 and 7, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.</p>			
Operating Limits and Warnings			

104R-1

SOLUTION SHEET FOR PROGRAM 104R

The following equations are given in the Shore Protection Manual:

$$\frac{d_b}{H_b} = \frac{1}{b - (aH_b/gT^2)} \quad (2-91)$$

$$a = 43.75(1 - e^{-1.9m}) \quad (2-92)$$

$$b = \frac{1.56}{(1 + e^{-19.5m})} \quad (2-93)$$

$$x_p = \tau_p H_b = (4.0 - 9.25 m) H_b \quad (7-3)$$

$$H_b = \frac{d_s}{\beta - m\tau_p} \quad (7-4)$$

Equation (7-4) can be rewritten in dimensionless form as:

$$\hat{H}_b = \frac{\hat{d}_s}{[(b - a\hat{H}_b)^{-1} - m\tau_p]}$$

where

$$\hat{H}_b = H_b/gT^2 \text{ and } \hat{d}_s = d_s/gT^2$$

The above equation can then be solved via the quadratic formula for $\hat{H}_b$ in terms of $\hat{d}_s$, τ_p , m , a , and b where the positive root provides useful results.

$$\hat{H}_b = \left\{ (m\tau_p b - a\hat{d}_s - 1) + [(m\tau_p b - a\hat{d}_s - 1)^2 + 4am\tau_p b\hat{d}_s]^{1/2} \right\} \cdot (2am\tau_p)^{-1}$$

This is the equation used in the program for design breaking wave height.

User Instructions

Program Title: 104R Depth-Limited Design Breaking Wave Height at Structure

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	ENTER BOTTOM SLOPE M (TANGENT)	m	A		M
2	ENTER DEPTH AT STRUCTURE ds (FEET OR METERS)	ds	B		ds
3	ENTER WAVE PERIOD T (SEC) PRESS E FOR ENGLISH UNITS PRESS F FOR METRIC UNITS	T(FT) T(M)	E F		
4	READ H _b IN DISPLAY				H _b (FT or m)
5	FOR NEW T GO TO STEP 3				
	NOTE: WITH PRINTER, m, ds, T, H _b ARE PRINTED AND LABELED				
	EXAMPLE:				
	ds = 10 FT, T = 10 SEC, m = 0.10				
	ENTER m = 0.10, PRESS A	0.10	A		0.10
	ENTER ds = 10 FT, PRESS B	10 FT	B		10.00
	ENTER T = 10 SEC, PRESS E	10 SEC	E		
	READ H _b = 17.98 IN DISPLAY				17.98

104R-3

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	F L B L A	31 25 11			.	83	
	STO 0	33 00	$m \rightarrow R_0$		5	05	
	RIS	84			6	06	
	F L B L B	31 25 12		060	$\div$	81	
	STO 7	33 07	$d_s \rightarrow R_7$		h Y X	35 62	
	RIS	84			STO 4	33 04	
	F L B L C	32 25 15			RCL 0	34 00	
	STO 9	33 09	$T \rightarrow R_9$		ENTER	41	
	9	09			9	09	
010	.	83			.	83	
	8	08			2	02	
	1	01			5	05	
	STO 8	33 08	$g(\text{METRIC}) \rightarrow R_8$		X	71	
	4 T O F d	22 31 14		070	4	04	
	F L B L E	31 25 15			-	51	
	STO 9	33 09	$T \rightarrow R_9$		CHS	42	
	3	03			RCL 0	34 00	
	2	02			X	71	
	.	83			STO 5	33 05	$m \tau_p = m(4 - 9.25m)$
020	2	02			RCL 4	34 04	$\rightarrow R_3$
	STO 8	33 08	$g(\text{ENGLISH}) \rightarrow R_8$		X	71	
	F L B L F d	32 25 14			1	01	
	RCL 7	34 07			-	51	
	RCL 8	34 08		080	RCL 1	34 01	
	$\div$	81			RCL 3	34 03	
	RCL 9	34 09			X	71	
	9 X ²	32 54			-	51	
	$\div$	81	$\frac{d_s}{g T^2} \rightarrow R_1$		STO 6	33 06	$m \tau_{pb} - a d_s - 1$
030	STO 1	33 01			9 X ²	32 54	$\rightarrow R_6$
	RCL 0	34 00			4	04	
	1	01			RCL 3	34 03	
	9	09			X	71	
	X	71			RCL 4	34 04	
	CHS	42		090	X	71	
	9 e ^x	32 52			RCL 5	34 05	
	CHS	42			X	71	
	1	01			RCL 1	34 01	
	+	61			X	71	
	4	04			+	61	
040	3	03			F V X	31 54	$((R_6)^2 + 4 a m \tau_p)^{1/2}$
	.	83			RCL 6	34 06	
	7	07			+	61	
	5	05			2	02	
	X	71		100	$\div$	81	
	STO 3	33 03	$43.75(1 - e^{-19m}) = a$		RCL 3	34 03	
	RCL 0	34 00	$\rightarrow R_3$		$\div$	81	
	1	01			RCL 5	34 05	
	9	09			$\div$	81	
	.	83			RCL 1	34 01	
050	5	05			$\div$	81	$\hat{H}_b = \frac{H_b}{g T^2}$
	X	71			RCL 7	34 07	
	CHS	42			X	71	
	9 e ^x	32 52		110	RIS	84	H_b IN DISPLAY
	1	01					
	+	61					
	1	01					

104R-4

Program Description

Program Title	104A Depth-Limited Design Breaking Wave Height at Structure (AOS logic)		
Name	W.A. Birkemeier	Date	5/81
Address	CERC Field Research Facility		
City	Kitty Hawk,	State	North Carolina Zip Code 27949

Program Description, Equations, Variables, etc.

This algorithm computes the depth-limited breaking wave height at a structure for design purposes. It can be used in lieu of Figure 7-4 of the Shore Protection Manual. The equation for the curves in Figure 7-4 is not given in the SPM but can be found by simultaneous solution of SPM equations (2-91), (2-92), (2-93), (7-3), and (7-4). Input is wave period, T , and water depth at the structure toe, d_s . The development of the equation is derived on the solution sheet included with program 104R. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vols. I and II, Chs. 2 and 7, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings

104A-1

User Instructions

Program Title: 104A Depth-Limited Design Breaking Wave Height
at structure

[illegible]

104A-2

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
000	76	LBL		054	08	08	
001	11	R		055	76	LBL	
002	42	STO	$M \rightarrow R_0$	056	19	D'	
003	00	00		057	03	3	*
004	03	3	* "M" PRINT CODE	058	07	7	*
005	00	0	*	059	69	OP	*
006	69	OP	*	060	04	04	*
007	04	04	*	061	43	RCL	*
008	43	RCL	*	062	09	09	*
009	00	00	*	063	69	OP	*
010	69	OP	* PRINT BOTTOM	064	06	06	*
011	06	06	* SLOPE M	065	43	RCL	
012	91	R/S		066	07	07	
013	76	LBL		067	55	+	
014	12	B		068	43	RCL	
015	42	STO	$d_s \rightarrow R_7$	069	08	08	
016	07	07		070	55	+	
017	01	1	*	071	43	RCL	
018	06	6	* "DS" PRINT CODE	072	09	09	
019	03	3	*	073	33	X2	
020	06	6	*	074	95	=	
021	69	OP	*	075	42	STO	
022	04	04	*	076	01	01	$\frac{d_s}{gT^2} \rightarrow R_1$
023	43	RCL	*	077	43	RCL	
024	07	07	*	078	00	00	
025	69	OP	*	079	65	X	
026	06	06	* PRINT d_s	080	01	1	
027	91	R/S		081	09	9	
028	76	LBL	E' ALLOWS METRIC	082	95	=	
029	10	E'	DATA ENTRY	083	94	+/-	
030	42	STO	$T \rightarrow R_9$	084	22	INV	
031	09	09		085	23	LNx	
032	09	9		086	94	+/-	
033	93	.	$g = 9.81$	087	85	+	
034	08	.8		088	01	1	
035	01	1		089	95	=	
036	42	STO	$g \rightarrow R_8$	090	65	X	
037	08	08		091	04	4	
038	03	3	*	092	03	3	
039	00	0	*	093	93	.	
040	69	OP	*	094	07	7	
041	04	04	*	095	05	5	
042	69	OP	* PRINT "M" TO	096	95	=	$43.75(1-e^{-9M})$
043	05	05	* INDICATE METRIC	097	42	STO	$\rightarrow R_3$
044	19	D'		098	03	03	
045	76	LBL		099	43	RCL	
046	15	E	E - ALLOWS ENGLISH	100	00	00	
047	42	STO	DATA ENTRY	101	65	X	
048	09	09	$T \rightarrow R_9$	102	01	1	
049	03	3		103	09	9	
050	02	2	$g = 32.2 \text{ ft/sec}^2$	104	93	.	
051	93	.		105	05	5	
052	02	2		106	95	=	
053	42	STO	$g \rightarrow R_8$	107	94	+/-	

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STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
108	25	LN		162	43	RCL	
109	23	LN		163	05	05	
110	85	+		164	65	x	
111	01	1		165	43	RCL	$4am\tau_p b \hat{d}_s$
112	95	=		166	01	01	
113	55	-		167	95	=	
114	01	1		168	34	FX	
115	93	.		169	85	+	
116	05	5		170	43	RCL	$((R_6)^2 + 4am\tau_p)^{1/2}$
117	06	6		171	06	06	
118	95	=	$\frac{1.56}{(1+e^{-9.5m})} = b$	172	95	=	
119	35	1/X		173	55	+	
120	42	STO		174	53	(	
121	04	04	$\rightarrow R_4$	175	02	2	
122	04	+		176	65	x	
123	75	-		177	43	RCL	
124	43	RCL		178	03	03	
125	00	00		179	65	x	
126	65	x		180	43	RCL	
127	09	9		181	05	05	$\hat{H}_b = \frac{H_b}{gT^2}$
128	93	.		182	95	=	
129	02	2		183	55	+	
130	05	5		184	43	RCL	
131	95	=		185	01	01	
132	65	x		186	65	x	
133	43	RCL		187	02	2	*
134	00	00		188	03	3	* "HB" PRINT CODE
135	95	=	$m\tau_p = (4 - 9.25m)m$	189	01	1	*
136	42	STO		190	04	4	*
137	05	05	$\rightarrow R_5$	191	69	DP	*
138	65	x		192	04	04	*
139	43	RCL		193	43	RCL	
140	04	04		194	07	07	
141	75	-		195	95	=	H_b
142	43	RCL		196	69	DP	*
143	03	03		197	06	06	* PRINT H_b
144	65	x		198	98	ADV	*
145	43	RCL		199	91	R/S	
146	01	01					
147	75	-					
148	01	1					
149	95	=	$m\tau_p b - a \hat{d}_s - 1$				
150	42	STO					
151	06	06	$\rightarrow R_6$				
152	33	X ²					
153	85	+					
154	04	4					
155	65	x					
156	43	RCL					
157	03	03					
158	65	x					
159	43	RCL					
160	04	04					
161	65	x					

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Program Description

Program Title	105R Wave Transmission - Fuchs' Equation (RPN logic)				
Name	T.L. Walton, Jr.		Date	10/80	
Address	Coastal Engineering Research Center				
City	Kingman Building	State	Virginia	Zip Code	22060
	Fort Belvoir,				

Program Description, Equations, Variables, etc.

This algorithm computes wavelength, L , in water depth, d , given the wave period, T . The program then computes wave transmission over a thin vertical barrier in water depth, d , using Fuchs' equation:

$$\frac{H_t}{H_i} = \sqrt{1 - \frac{\frac{4\pi h}{L} + \sinh \frac{4\pi h}{L}}{\frac{4\pi d}{L} + \sinh \frac{4\pi d}{L}}}$$

where H_t is the transmitted wave height, H_i the incident wave height, and h the height of barrier. Note that this equation *cannot* be used when wave transmission is by overtopping of a structure. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. II, Ch. 7, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977, p. 7-62.

Operating Limits and Warnings

105R-1

User Instructions

Program Title: 105R Wave Transmission - Fuchs' Equation

[illegible]

105R-2

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	FLBLA	31 25 11	ENTER d		RCL 3	34 05	
	ENTER	41			+	61	
	2	02			2	02	
	X	71		060	÷	81	
	h π	35 73			STO 2	33 02	$L_{NEW} \rightarrow R_2$
	X	71			RCL 3	34 03	
	STO 0	33 00	$2\pi d \rightarrow R_0$		-	51	
	RIS	84			h ABS	35 64	
	FLBLB	31 25 12	ENTER h		1	01	
010	STO 8	33 08			$3 \times Y$	32 81	
	RIS	84			GTO FC	22 31 13	
	$\frac{1}{2}$ LBLFe	32 25 15			RCL 2	34 02	
	STO 7	33 07	$T \rightarrow R_7$		GTO Fd	22 31 14	
	9	09		070	$\frac{1}{2}$ LBLFc	32 25 13	
	.	83			RCL 2	34 02	
	8	08			RIS	84	L IN DISPLAY
	1	01			h Yx	35 62	
	STO 6	33 06	$g(METRIC) \rightarrow R_6$		RCL 0	34 00	
	GTO Fb	22 31 12			X	71	
020	FLBLE	31 25 15			2	02	
	STO 7	33 07	$T \rightarrow R_7$		X	71	
	3	03			STO 6	33 06	$\frac{4\pi d}{L} \rightarrow R_6$
	2	02			F GSB 1	31 22 01	
	.	83		080	RCL 6	34 06	
	2	02			+	61	
	STO 6	33 06	$g(ENGLISH) \rightarrow R_6$		STO 7	33 07	$R_6 + \sinh(R_6) \rightarrow R_7$
	$\frac{1}{2}$ LBLFb	32 25 12			A	04	
	RCL 7	34 07			ENTER	41	
	$g X^2$	32 54			h π	35 73	
030	RCL 6	34 06			X	71	
	X	71			RCL 8	34 08	
	2	02			X	71	
	÷	81			RCL 2	34 02	
	h π	35 73		090	÷	81	
	÷	81			STO 9	33 09	$\frac{4\pi h}{L} \rightarrow R_9$
	STO 1	33 01	$L_0 \rightarrow R_1$		F GSB 1	31 22 01	
	$\frac{1}{2}$ LBLFd	32 25 14			RCL 9	34 09	
	STO 3	33 03	$L_{LOW} \rightarrow R_3$		+	61	
	h Yx	35 62			RCL 7	34 07	
040	RCL 0	34 00			÷	81	
	X	71			CHS	42	
	STO 4	34 04	$2\pi d_{LOW} \rightarrow R_4$		1	01	
	$g e^x$	32 52			+	61	
	RCL 4	34 04		100	F Yx^1	31 54	
	CHS	42			RIS	84	H_T/H_L IN DISPLAY
	$g e^x$	32 52			FLBLI	31 25 01	
	-	51			STO 5	33 05	
	RCL 4	34 04			$g e^x$	32 52	
	$g e^x$	32 52			RCL 5	34 05	
050	RCL 4	34 04			CHS	42	
	CHS	42			$g e^x$	32 52	
	$g e^x$	32 52			-	51	
	+	61			2	02	
	÷	81	$\tanh \frac{2\pi d}{L_{LOW}}$	110	÷	81	
	RCL 1	34 01			h RTN	35 22	
	X	71					

Program Description

Program Title	105A Wave Transmission - Fuchs' Equation (AOS logic)		
Name	W.A. Birkemeier	Date	5/81
Address	CERC Field Research Facility		
City	Kitty Hawk,	State	North Carolina Zip Code 27949

Program Description, Equations, Variables, etc.

This algorithm computes wavelength, L , in water depth, d , given the wave period, T . The program then computes wave transmission over a thin vertical barrier in water depth, d , using Fuchs' equation:

$$\frac{H_t}{H_i} = \sqrt{1 - \frac{\frac{4\pi d}{L} + \sinh \frac{4\pi d}{L}}{\frac{4\pi d}{L} + \sinh \frac{4\pi d}{L}}}$$

where H_t is the transmitted wave height, H_i the incident wave height, and h the height of barrier. Note that this equation *cannot* be used when wave transmission is by overtopping of a structure. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. II, Ch. 7, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977, p. 7-62.

Operating Limits and Warnings

105A-1

User Instructions

Program Title: 105A Wave Transmission - Fuchs' Equation

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	ENTER WATER DEPTH (d) IN FEET OR METERS	d (ft) OR d (m)	<input type="text"/>	<input type="text"/>	d
2	ENTER SILL HEIGHT (h) IN FEET OR METERS (WITH PRINTER, LABEL READS SH FOR SILL HEIGHT)	h (ft) OR h (m)	<input type="text"/>	<input type="text"/>	h
3	ENTER WAVE PERIOD T (SEC) PRESS E FOR ENGLISH UNITS PRESS E' FOR METRIC UNITS	T (SEC) T (SEC)	<input type="text"/>	<input type="text"/>	
4	WITH PRINTER L ₀ , L, H _t /H _i ARE PRINTED AND LABELED, L ₀ AND L ARE COMPUTED IN INPUT UNITS, WITHOUT PRINTER: READ L ₀ PRESS R/S READ L PRESS R/S READ H _t /H _i		<input type="text"/>	<input type="text"/>	L ₀ L H _t /H _i
5	TO REPEAT FOR NEW T GO TO STEP 3		<input type="text"/>	<input type="text"/>	L ₀ L H _t /H _i
	EXAMPLE		<input type="text"/>	<input type="text"/>	
	d = 15 ft, h = 10 ft, T = 10 SEC		<input type="text"/>	<input type="text"/>	
	ENTER d = 15 PRESS A	15 ft	A	<input type="text"/>	15
	ENTER h = 10 PRESS B	10 ft	B	<input type="text"/>	10
	ENTER T = 10 PRESS E	10 SEC	E	<input type="text"/>	10
	READ L ₀ = 512.48		<input type="text"/>	<input type="text"/>	512.48
	PRESS R/S (IF REQUIRED) READ L = 213.02		<input type="text"/>	<input type="text"/>	213.02
	PRESS R/S (IF REQUIRED) READ H _t /H _i		<input type="text"/>	<input type="text"/>	0.598
	PRINTOUT OF EXAMPLE		<input type="text"/>	<input type="text"/>	
	15. D		<input type="text"/>	<input type="text"/>	
	10. SH		<input type="text"/>	<input type="text"/>	
	10. T		<input type="text"/>	<input type="text"/>	
	512.4789168 L ₀		<input type="text"/>	<input type="text"/>	
	213.0238318 L		<input type="text"/>	<input type="text"/>	
	0.597721319 H _t /H _i		<input type="text"/>	<input type="text"/>	

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Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
000	76	LBL		055	02	2	
001	11	R		056	93	.	
002	42	STO	d → R ₀	057	02	2	
003	00	00		058	42	STO	g → R ₆
004	65	x		059	06	06	
005	01	1	*	060	76	LBL	
006	06	6	*	061	17	B'	
007	69	DP	*	062	03	3	*
008	04	04	*	063	07	7	*
009	02	2		064	69	DP	*
010	65	x		065	04	04	*
011	89	9		066	43	RCL	
012	95	=		067	07	07	
013	48	EXC	2nd → R ₀	068	69	DP	*
014	00	00		069	06	06	*
015	69	DP	*	070	33	X ²	
016	06	06	*	071	65	x	
017	91	R/S		072	43	RCL	
018	76	LBL		073	06	06	
019	12	B		074	55	+	
020	42	STO	h → R ₈	075	02	2	
021	08	08		076	55	+	
022	03	3	*	077	02	2	*
023	06	6	*	078	07	7	*
024	02	2	*	079	03	3	*
025	03	3	*	080	02	2	*
026	69	DP	*	081	69	DP	*
027	04	04	*	082	04	04	*
028	43	RCL	*	083	89	9	
029	08	08	*	084	95	=	
030	69	DP	*	085	42	STO	L ₀ → R ₁
031	06	06	*	086	01	01	
032	91	R/S		087	69	DP	*
033	76	LBL	STEPS 33 TO 49	088	06	06	*
034	10	E'	ALLOW METRIC	089	76	LBL	
035	42	STO	INPUT/OUTPUT	090	14	D	
036	07	07		091	01	1	
037	09	9		092	32	XIT	
038	93	.		093	43	RCL	
039	08	8		094	01	01	
040	01	1		095	76	LBL	
041	42	STO		096	19	D'	
042	06	06		097	42	STO	L _{OLD} → R ₃
043	03	3	*	098	03	03	
044	00	0	*	099	35	1/X	
045	69	DP	*	100	65	x	
046	04	04	*	101	43	RCL	
047	69	DP	*	102	00	00	
048	05	05	*	103	95	=	
049	17	B'		104	42	STO	2nd → R ₄
050	76	LBL		105	04	04	L _{OLD}
051	15	E		106	22	INV	
052	42	STO	STEPS 50 TO 59	107	23	LNN	
053	07	07	ALLOW ENGLISH	108	75	-	
054	03	3	INPUT/OUTPUT	109	48	END	
			T → R ₇				

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R/S-INSERT IF PRINTER IS NOT AVAILABLE

105A-3

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
110	04	04		165	42	STD	$4\pi d/L \rightarrow R_6$
111	34	+/-		166	06	06	
112	22	INV		167	71	SBR	
113	23	LHX		168	38	SIN	$\sinh\left(\frac{4\pi d}{L}\right)$
114	42	STD		169	85	+	
115	05	05		170	43	RCL	
116	95	=		171	06	06	
117	55	-		172	95	=	
118	53	(		173	42	STD	$4\pi d/L + \sinh\left(\frac{4\pi d}{L}\right)$
119	43	RCL		174	07	07	
120	04	04		175	04	+	$\rightarrow R_7$
121	85	+		176	65	*	
122	43	RCL		177	89	+	
123	05	05		178	65	*	
124	95	=	$\tanh 2\pi d/L_{old}$	179	43	RCL	
125	65	*		180	08	08	
126	43	RCL		181	55	+	
127	01	01		182	43	RCL	
128	85	+		183	02	02	
129	43	RCL		184	95	=	
130	03	03		185	42	STD	$4\pi h/L \rightarrow R_9$
131	95	=		186	09	09	
132	55	+		187	71	SBR	
133	02	2		188	38	SIN	$\sinh\left(\frac{4\pi h}{L}\right)$
134	95	=		189	85	+	
135	42	STD	$L_{NEW} \rightarrow R_2$	190	43	RCL	$\frac{4\pi h}{L} + \sinh\left(\frac{4\pi h}{L}\right)$
136	02	02		191	09	09	
137	75	-		192	95	=	
138	43	RCL	$L_{NEW} - L_{old}$	193	55	+	
139	03	03		194	43	RCL	
140	95	=		195	07	07	
141	50	IXI		196	95	=	
142	22	INV		197	94	+/-	
143	77	GE	ITERATE TO	198	85	+	
144	18	C'	COMPUTE L	199	02	2 *	
145	43	RCL		200	03	3 *	"H/H" PRINT CODE
146	02	02		201	06	6 *	
147	19	D'		202	03	3 *	
148	76	LBL		203	02	2 *	
149	18	C'		204	03	3 *	
150	02	2 *	"L" PRINT CODE	205	69	DP *	
151	07	7 *		206	04	04 *	
152	69	DP *		207	01	1	
153	04	04 *		208	95	=	
154	43	RCL		209	34	FX	
155	02	02		210	69	DP *	
156	69	DP *	PRINT L	211	06	06 *	PRINT H_t/H_i
157	06	06 *		212	98	ADV *	
158	35	1/X		213	91	R/S	
159	65	*		214	76	LBL	STEPS 214 TO
160	43	RCL		215	38	SIN	235 COMPUTE
161	00	00		216	42	STD	$\sinh(R_{11})$
162	65	*		217	11	11	
163	02	2		218	22	INV	
164	95	=		219	23	LHX	

105A-4

[illegible]

APPENDIX
BLANK PROGRAM FORMS

Program Description

Program Title		
Name		Date
Address		
City	State	Zip Code
Program Description, Equations, Variables, etc.		
Operating Limits and Warnings		

User Instructions

Program Title

[illegible]

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001							
				060			
010							
				070			
020							
				080			
030							
				090			
040							
				100			
050							
				110			

<p>Walton, Todd L. (Todd Leon) Hand-held calculator algorithms for coastal engineering / by Todd L. Walton, Jr., William A. Birkemeier, and J. Richard Weggel.-- Fort Belvoir, Va. : U.S. Army Coastal Engineering Research Center ; Springfield, Va. : available from NTIS, 1982. [71] p. : forms ; 28 cm.--(Coastal engineering technical aid ; no. 82-1). Cover title. "January 1982." Report provides algorithms for a number of calculator programs useful in performing coastal engineering calculations, primarily in the area of wave transformations and wave generation. Six programs are included with different versions for use with hand-held calculators which employ either the Reverse Polish Notation (RPN) or the Algebraic Operating System (AOS). 1. Coastal engineering--Data processing. 2. Calculating--machines. 3. Algorithms. 4. Wave transformation--Data processing. 5. Wave generation--Data processing. I. Birkemeier, William A. II. Weggel, J. Richard (John Richard), 1941. III. Title. IV. Series. TC203 .U581ta no. 82-1 627</p>	<p>Walton, Todd L. (Todd Leon) Hand-held calculator algorithms for coastal engineering / by Todd L. Walton, Jr., William A. Birkemeier, and J. Richard Weggel.-- Fort Belvoir, Va. : U.S. Army Coastal Engineering Research Center ; Springfield, Va. : available from NTIS, 1982. [71] p. : forms ; 28 cm.--(Coastal engineering technical aid ; no. 82-1). Cover title. "January 1982." Report provides algorithms for a number of calculator programs useful in performing coastal engineering calculations, primarily in the area of wave transformations and wave generation. Six programs are included with different versions for use with hand-held calculators which employ either the Reverse Polish Notation (RPN) or the Algebraic Operating System (AOS). 1. Coastal engineering--Data processing. 2. Calculating--machines. 3. Algorithms. 4. Wave transformation--Data processing. 5. Wave generation--Data processing. I. Birkemeier, William A. II. Weggel, J. Richard (John Richard), 1941. III. Title. IV. Series. TC203 .U581ta no. 82-1 627</p>
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