UNITED STATES DEPARTMENT OF INTERIOR

GEOLOGICAL SURVEY

Texas Instruments Model 59 Hand-Calculator Program to Calculate Magnetic Anomaly over 2-D Prisms of up to 12 Vertices

By

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TITLE MAGNETICS: 2-D ANOMALY PAGE 1 OF 12

PROGRAMMER Donald N. Haines and David L. Campbell DATE 6/28/78

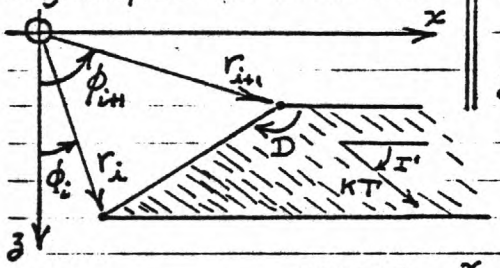
TI Programmable **Program Record**

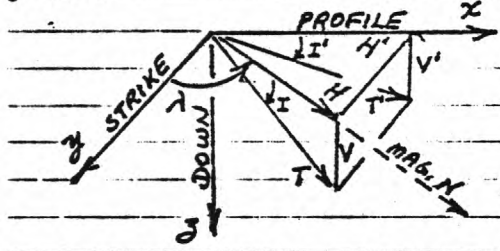
Partitioning (Op 17) 6,3,9,3,9 (4 2nd Op 17) Library Module None used Printer Optional Cards 2

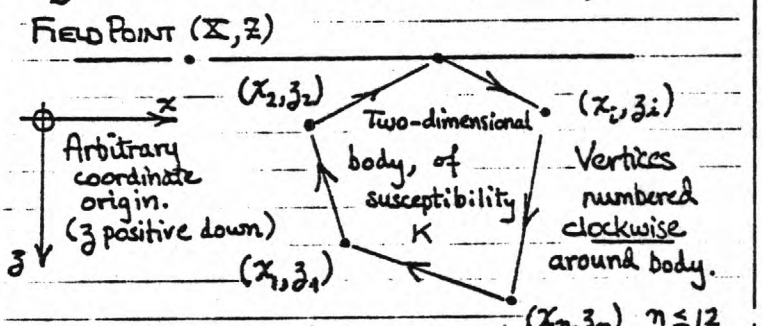
PROGRAM DESCRIPTION

Program Description, Equations, Variables, etc. A Talwani-type program to calculate $\Delta T'$, $\Delta H'$, or $\Delta V'$ magnetic anomaly due to 2-dimensional prism of ≤ 12 vertices.

Equations: Field is superposition of fields due to n angle-edged horizontal plates like the one below:







$$\Delta T' = 2KTh^2 \sin D\left[\sin(2I'-D)\,\Delta\phi + \cos(2I'-D)\,\Delta \ln R\right]$$

$$\Delta H' = 2KTh \sin D\left[\sin(I'-D)\,\Delta\phi + \cos(I'-D)\,\Delta \ln R\right]$$

$\Delta V'$ = same as $\Delta H'$, with $I' \leftarrow I' + \frac{\pi}{2}$

$h^2 = 1 - \cos^2 I \cos^2 \lambda$ $\quad I' = \tan^{-1}\left(\frac{\tan I}{\sin \lambda}\right)$

$\Delta\phi = \phi_{i+1} - \phi_i$ $\quad \Delta \ln R = \ln r_{i+1} - \ln r_i$

I = field inclination; λ = angle, strike to mag N.

Unprimed coordinates represent earth's true field;
Primed coordinates are projected into x-z plane.

Reference: Hiertzler, J.R., Peter, G., Talwani, M., and Zurfluch, E.G., 1962, Lamont Geol. Obs. (Columbia Univ.) Tech. Rept. #6, CU-6-62 (Note I've changed some notation in obvious ways.)

Operating Limits and Warnings GENERAL: Equations used assume body has negligible remenant magnetization, negligible demagnetization effect, and that $\Delta T' << T$. This last condition is usually met if susceptibility $K << 1$.

USER DEFINED KEYS	DATA REGISTERS (INV Int)		LABELS (Op 08)
A K·T	0 Index n	30 ΔX	
B I	1 Loop index i	31 2I'-D or I'-D	
C λ	2 K·T	32 $\Sigma \Delta F_i'$	
D Body vertex x z	3 I	33 R_{i+1}/R_i	
E Field point X Z	4 λ	34 $\Delta\phi_i$	
A' —	5–28 ↑	35 D_i	
B' —		36 h^2	
C' —	Body vertices	37 I'	
D' Body index i		38 X	
E' ΔX	↓	39 Z	

FLAGS — 0	— 1	ΔV' Field?	— 3	— 4	— 5	6	7	8	9

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TITLE Magnetics: 2-D Anomaly PAGE 2 OF 12

PROGRAMMER Donald N. Haines and David L. Campbell DATE

TI Programmable **Program Record**

Partitioning (Op 17) 639.39 Library Module None used Printer Optional Cards 2

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Read in both sides of Card 1. To do this:					
	(a) Turn calculator on. If it is already on, turn it off, and then back on to clear possibly troublesome display formats.					
	(b) Set partitioning, like this:	4	2nd	Op	17	639.39
	(c) Enter"0." and feed in Side 1 of Card 1. Display will show "1.".					
	(d) Enter "0." and feed in Side 2 of Card 1. Display will show "3.". If display blinks, something failed, so repeat the step.					
2	Read in the proper side of Card 2:					
	(a) To calculate ΔT', enter "0." and feed in Side 1. Display will show "2.".					
	(b) To calculate either ΔH' or ΔV', enter "0." and feed in Side 2. Display will show "2.".					
3	If ΔV' is to be calculated, press		2nd	St flg	2	
	● Flag 2 must be cleared to calculate either ΔT' or ΔH'. To clear Flag 2, press	Inv	2nd	St flg	2	
4	Enter field parameters (in any order)					
	(a) Susceptibility x field strength	KT			A	
	(b) Field inclination	I(deg)			B	
	(c) Angle, mag N to strike	λ(deg)			C	
5	Input body vertices					
	(a) Initialize	(k=) 1		2nd	D	0
	(b) Enter successive body vertices working clockwise around body.					
		x_i			x⇄t	
		z_i			D	i
	● Up to 12 vertices may be entered. Flashing "12." in display after this step means you tried to enter too many. Note vertex #1 is not repeated to close the body, as in some programs.					
6	(Optional) To calculate points on a profile (Z constant)	ΔX		2nd	E	ΔX
7	Enter field points	X			x⇄t	
		Z			E	Δg mgals
	● Repeat step for other field points, as desired, or press R/S for next incremented X.					
	● Flashing "2." means flag 2 is set during an attempt to calculate ΔT.					

PROGRAMMER _____ DATE _____

TI Programmable **Program Record**

Partitioning (Op 17) ⌊ . . . . ⌋ Library Module _____ Printer _____ Cards _____

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
8	To change body vertex k	k		2nd	D	n-1
		x_k			x⇄t	
		z_k			D	n=total no. of body points
	● Body vertex k (only) is changed via step 8. However, body vertex #1 may not be changed this way, for program then thinks it is at step 5a, and that a new body is being initiated. In this case, all body points must be re-entered.					
	● Body may be extended at any time via step 5b. This adds new body points, starting from previous nth body point.					
	● Steps 2 through 8 may be performed in various sequences, including between field calculations, to see the effect of changing one such parameter.					
9	To start a new body, clear			2nd	CMS	and go to step 4.

CARD LAYOUT

1 ◇ ▷3

MAGNETICS: 2-D Anomaly – Card 1 – 4 Op 17

			Bod. index	ΔX
KT	I	λ	x, z	X, Z

2 ◇ ▷2

MAGNETICS: 2-D Anomaly – Card 2 – 4 Op 17

← Read this side for	ΔT'	
Read this side	for ΔH', ΔV' →	

Comments

1. This program calculates magnetic fields due to only one body at a time. Still, multi-body models may be treated by using the program to calculate magnetic anomaly for each body separately, and then manually adding component fields at the desired field points.

WARNING: This procedure gives an adequate approximation only when each component body separately satisfies the conditions listed on page 1--no remanent magnetization, very small magnetic susceptibility, negligible demagnetization effect, and small (vector) anomalous field compared with (vector) magnetizing field.

2. This program is appropriate for simple or in-the-field applications. However, it is quite slow, taking approximately 20 seconds per body vertex for each field point calculation. Therefore, even moderately complicated bodies will take several minutes calculating time per field point. (Plan something else to do during the waiting intervals!) Clearly, complex or multi-body problems are better handled on a more time-efficient computer system.

3. Indeterminate answers (flashing "9.9999999 99") may result (i) when input field points lie on a body vertex, and (ii) when field points lie on an extension of a body side. Treat such cases by recalculating the field at nearby field points which have been migrated a small distance away from the objectionable location.

4. When using the profile option (step 6), the program will pause right after R/S is pressed (step 7) with the incremented X value in display. This feature is for the convenience of users who have no print cradle. The current field point can also be recovered--after the $\Delta F'$ calculation has run to completion--by pressing "RCL 38" (display shows X) and "RCL 39" (display shows Z).

5. The X-profile option easily may be modified to a Z-profile option (for example, for drill hole calculations) by making the following changes on Card 2:

a. Change "SUM 38" (in addresses 457 and 458 on Side 1 and addresses 463 and 464 on Side 2) to "SUM 39".

b. Insert "Pause" after address 464 on Side 1 and after address 470 on Side 2.

c. Delete "Pause" command at address 461 on Side 1 and at address 467 on Side 2.

At instruction step 6, ΔZ is then entered in place of the current ΔX.

TITLE Side 1 of Card 1-1 PAGE 5 OF 12

~~PROGRAMMER~~ (Magnetics: 2-D) DATE

TI Programmable **Coding Form**

LOC	CODE	KEY	COMMENTS
000	76	LBL	Fcn A:
001	11	A	
002	42	STO	
003	02	02	Store KT
004	69	OP	
005	00	00	
006	02	2	
007	06	6	
008	00	0	
009	00	0	
010	05	5	
011	00	0	
012	00	0	
013	00	0	Print
014	69	OP	
015	01	01	"K x FIELD"
016	02	2	
017	01	1	
018	02	2	
019	04	4	
020	01	1	
021	07	7	
022	02	2	
023	07	7	
024	01	1	
025	06	6	
026	69	OP	
027	02	02	
028	69	OP	
029	05	05	
030	43	RCL	
031	02	02	
032	99	PRT	Print KT
033	25	CLR	
034	91	R/S	
035	76	LBL	Fcn B:
036	12	B	
037	42	STO	
038	03	03	Store I
039	69	OP	
040	00	00	
041	02	2	
042	01	1	
043	02	2	
044	04	4	
045	01	1	
046	07	7	
047	02	2	
048	07	7	
049	69	OP	
050	01	01	
051	01	1	
052	06	6	
053	00	0	
054	00	0	
055	02	2	
056	04	4	Print
057	03	3	
058	01	1	"FIELD
059	01	1	INCLIN."
060	05	5	
061	69	OP	
062	02	02	
063	02	2	
064	07	7	
065	02	2	
066	04	4	
067	03	3	
068	01	1	
069	04	4	
070	00	0	
071	00	0	
072	00	0	
073	69	OP	
074	03	03	
075	69	OP	
076	05	05	
077	43	RCL	
078	03	03	
079	99	PRT	Print I
080	25	CLR	
081	91	R/S	
082	76	LBL	Fcn C:
083	13	C	
084	42	STO	
085	04	04	Store λ
086	69	OP	
087	00	00	
088	03	3	
089	06	6	
090	03	3	
091	07	7	
092	03	3	
093	05	5	
094	02	2	
095	04	4	Print
096	69	OP	"STRIKE"
097	01	01	
098	02	2	
099	06	6	
100	01	1	
101	07	7	
102	00	0	
103	00	0	
104	00	0	
105	00	0	
106	00	0	
107	00	0	
108	69	OP	
109	02	02	
110	69	OP	
111	05	05	
112	43	RCL	
113	04	04	
114	99	PRT	Print λ
115	91	R/S	
116	76	LBL	Fcn D':
117	19	D'	
118	32	X:T	
119	01	1	If i=1,
120	22	INV	zero the
121	67	EQ	body pt
122	89	π	counter.
123	42	STO	
124	01	01	
125	76	LBL	
126	89	π	
127	32	X:T	
128	65	×	
129	02	2	Convert
130	85	+	bodpt index
131	02	2	i to
132	95	=	storage index
133	42	STO	j.
134	00	00	
135	69	OP	Decrement
136	31	31	bodpt counter.
137	76	LBL	
138	91	R/S	R/S: Display
139	43	RCL	
140	01	01	xi-1 or i.
141	98	ADV	
142	91	R/S	
143	76	LBL	Fcn D:
144	14	D	
145	71	SBR	Temp. store
146	45	Y×	x_i, z_i.
147	43	RCL	
148	00	00	
149	55	÷	
150	02	2	
151	75	-	
152	01	1	Calculate
153	95	=	i from j.
154	32	X:T	
155	01	1	
156	03	3	Check for
157	32	X:T	too many
158	77	GE	bodpts.
159	77	GE	

MERGED CODES

62 Prm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

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TI-24151

TITLE Side 1 of Card 1-2 PAGE 6 OF 12

PROGRAMMER ~~MAGNETICS: 2D~~ DATE

TI Programmable **Coding Form**

LOC	CODE	KEY	COMMENTS
160	71	SBR	Get TI print code for i.
161	80	GRD	
162	85	+	
163	01	1	
164	95	=	
165	69	□P	
166	03	03	
167	01	1	
168	04	4	
169	03	3	
170	02	2	
171	01	1	
172	06	6	
173	04	4	
174	05	5	
175	69	□P	Print "BODY
176	01	01	"BODY
177	03	3	PT. i"
178	03	3	
179	03	3	
180	07	7	
181	04	4	
182	00	0	
183	69	□P	
184	02	02	
185	69	□P	
186	05	05	
187	69	□P	Print x,z
188	21	21	
189	43	RCL	
190	38	38	
191	99	PRT	and
192	69	□P	
193	20	20	
194	72	ST*	
195	00	00	Store x,z
196	69	□P	
197	20	20	
198	43	RCL	
199	39	39	
200	99	PRT	
201	72	ST*	
202	00	00	
203	61	GTO	
204	91	R/S	
205	76	LBL	GE:
206	77	GE	
207	01	1	Display
208	04	4	flashing
209	04	4	"12."
210	94	+/-	for ≥12
211	34	FX	input
212	95	=	bodpts.
213	91	R/S	
214	76	LBL	Yˣ:

LOC	CODE	KEY	COMMENTS
215	45	Yˣ	
216	32	X:T	Subr. for
217	42	STO	temp.
218	38	38	storage
219	32	X:T	of x,z
220	42	STO	pairs.
221	39	39	
222	69	□P	
223	00	00	
224	92	RTN	
225	76	LBL	Deg:
226	60	DEG	
227	01	1	TI print
228	01	1	code for "9"
229	92	RTN	
230	76	LBL	Rad:
231	70	RAD	
232	85	+	TI print
233	01	1	code for
234	09	9	10, 11, 12
235	00	0	
236	95	=	
237	92	RTN	
238	00	0	
239	00	0	

LOC	CODE	KEY	COMMENTS

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

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TITLE Side 2 of Card 1-1 PAGE 7 OF 12

PROGRAMMER MAGNETICS: 2-D DATE

TI Programmable **Coding Form**

LOC	CODE	KEY	COMMENTS
480	76	LBL	Fcn E':
481	10	E'	
482	42	STO	Store ΔX
483	30	30	
484	91	R/S	
485	76	LBL	Fcn E:
486	15	E	
487	71	SBR	Temp. store
488	45	Y×	fieldpt X,Z
489	60	DEG	
490	25	CLR	
491	42	STO	Zero ΔF'
492	32	32	register.
493	02	2	
494	01	1	
495	02	2	
496	04	4	
497	01	1	
498	07	7	
499	02	2	
500	07	7	
501	69	OP	Print
502	01	01	"FIELD
503	01	1	PT."
504	06	6	
505	00	0	
506	00	0	
507	03	3	
508	03	3	
509	03	3	
510	07	7	
511	04	4	
512	00	0	
513	69	OP	
514	02	02	
515	69	OP	
516	05	05	
517	43	RCL	
518	38	38	Print
519	99	PRT	X
520	43	RCL	Z
521	39	39	
522	99	PRT	
523	01	1	
524	03	3	
525	03	3	Store
526	01	1	"ANOM"
527	03	3	in print
528	02	2	register.
529	03	3	
530	00	0	
531	69	OP	
532	02	02	
533	43	RCL	
534	03	03	

LOC	CODE	KEY	COMMENTS
535	30	TAN	
536	55	÷	
537	43	RCL	Calculate
538	04	04	
539	38	SIN	I'
540	95	=	
541	22	INV	
542	30	TAN	
543	42	STO	
544	37	37	
545	22	INV	If flag 2
546	87	IFF	is set,
547	02	02	(ΔV' field)
548	49	PRD	replace
549	09	9	I' with
550	00	0	I'+90°
551	44	SUM	
552	37	37	
553	76	LBL	
554	49	PRD	
555	43	RCL	
556	03	03	
557	39	COS	
558	33	X²	
559	65	×	
560	43	RCL	Calculate
561	04	04	
562	39	COS	h²
563	33	X²	
564	94	+/-	
565	85	+	
566	01	1	
567	95	=	
568	42	STO	
569	36	36	
570	61	GTO	Go to 240
571	02	02	(Card 2
572	40	40	subroutine)
573	76	LBL	P/R:
574	37	P/R	
575	73	RC*	
576	00	00	
577	94	+/-	
578	32	X↕T	
579	69	OP	
580	20	20	
581	73	RC*	
582	00	00	
583	94	+/-	
584	53	(	
585	32	X↕T	
586	69	OP	
587	20	20	
588	85	+	
589	73	RC*	

LOC	CODE	KEY	COMMENTS
590	00	00	
591	54	)	Subroutine
592	53	(	to
593	32	X↕T	calculate
594	69	OP	angle
595	20	20	
596	85	+	D_i
597	73	RC*	
598	00	00	
599	54	)	
600	22	INV	
601	37	P/R	
602	42	STO	
603	35	35	
604	03	3	
605	22	INV	
606	44	SUM	
607	00	00	
608	29	CP	
609	92	RTN	
610	76	LBL	Int:
611	59	INT	
612	53	(	
613	53	(	Subroutine
614	43	RCL	to restore
615	00	00	loop
616	75	-	register
617	04	4	value.
618	54	)	
619	55	÷	
620	02	2	
621	54	)	
622	42	STO	
623	01	01	
624	92	RTN	
625	76	LBL	Grd:
626	80	GRD	
627	32	X↕T	Find TI
628	09	9	print code
629	32	X↕T	for
630	67	EQ	bodpt
631	60	DEG	index i.
632	77	GE	
633	70	RAD	
634	92	RTN	
635	00	0	
636	00	0	
637	00	0	
638	00	0	
639	00	0	

MERGED CODES

62 Prd Ind | 72 STO Ind | 83 GTO Ind
63 Exc Ind | 73 RCL Ind | 84 Op Ind
64 Prd Ind | 74 SUM Ind | 92 INV SBR

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TITLE Side 1 of Card 2-1 PAGE 8 OF 12 TI Programmable

PROGRAMMER MAGNETICS: 2-D DATE

Coding Form

LOC	CODE	KEY	COMMENTS
240	22	INV	Start calc. for ΔT':
241	87	IFF	
242	02	02	
243	79	x̄	Display "2." flashing if flag 2 is set.
244	04	4	
245	94	+/-	
246	34	fX	
247	91	R/S	
248	76	LBL	
249	79	x̄	x̄:
250	03	3	
251	07	7	
252	03	3	Store "TOT." in print register.
253	02	2	
254	03	3	
255	07	7	
256	04	4	
257	00	0	
258	69	□P	
259	01	01	
260	69	□P	
261	05	05	
262	69	□P	
263	00	00	
264	04	4	Initialize index j.
265	42	STO□	
266	00	00	
267	76	LBL	Sum:
268	44	SUM	
269	69	□P	
270	20	20	
271	43	RCL	
272	38	38	
273	94	+/-	Shift origin to this field point.
274	74	SM*	
275	00	00	
276	69	□P	
277	20	20	
278	43	RCL	
279	39	39	
280	94	+/-	
281	74	SM*	
282	00	00	
283	97	DSZ	
284	01	01	
285	44	SUM	
286	71	SBR	Restore loop reg.
287	59	INT	
288	05	5	Initialize index reg.
289	42	STO□	
290	00	00	
291	76	LBL	DSZ: Main loop entry
292	97	DSZ	
293	71	SBR	
294	37	P/R	Get D_i
295	01	1	
296	32	X:T	
297	43	RCL	Test if i+1 vertex equals 1st vertex
298	01	01	
299	22	INV	
300	67	EQ	
301	28	LOG	
302	43	RCL	
303	05	05	If so,
304	75	-	
305	73	RC*	Get D_i using 1st vertex as i+1st vertex...
306	00	00	
307	95	=	
308	32	X:T	
309	69	□P	
310	20	20	
311	43	RCL	
312	06	06	
313	75	-	
314	73	RC*	
315	00	00	
316	95	=	
317	22	INV	
318	37	P/R	
319	42	STO□	
320	35	35	
321	69	□P	
322	30	30	
323	76	LBL	Log:
324	28	LOG	
325	73	RC*	
326	00	00	Recall coords for calc. of $\Delta\phi_i$, R_{in}/R_i
327	32	X:T	
328	69	□P	
329	20	20	
330	73	RC*	
331	00	00	
332	22	INV	
333	37	P/R	
334	42	STO□	
335	34	34	
336	32	X:T	
337	35	1/X	
338	42	STO□	
339	33	33	
340	69	□P	
341	20	20	
342	01	1	
343	32	X:T	Test if i+1 vertex equals 1st vertex
344	43	RCL	
345	01	01	
346	67	EQ	
347	32	X:T	
348	73	RC*	
349	00	00	
350	32	X:T	
351	69	□P	
352	20	20	
353	73	RC*	
354	00	00	
355	61	GTO□	
356	69	□P	
357	76	LBL	x⇄t:
358	32	X:T	
359	43	RCL	If so, use x_1, z_1 as i+1st vertex.
360	05	05	
361	32	X:T	
362	43	RCL	
363	06	06	
364	76	LBL	Op:
365	69	□P	
366	22	INV	
367	37	P/R	Get $\Delta\phi_i$, R_{in}/R_i
368	22	INV	
369	44	SUM	
370	34	34	
371	32	X:T	
372	49	PRD	
373	33	33	
374	69	□P	
375	30	30	
376	53	(	
377	53	(	
378	02	2	Get $2I'-D_i$
379	65	×	
380	43	RCL	
381	37	37	
382	75	-	
383	43	RCL	
384	35	35	
385	54	)	
386	42	STO□	
387	31	31	
388	38	SIN	Convert $\Delta\phi_i$ to radians & mult by $\sin(2I'-D)$
389	65	×	
390	89	π	
391	55	÷	
392	01	1	
393	08	8	
394	00	0	
395	65	×	
396	43	RCL	
397	34	34	
398	85	+	
399	43	RCL	

MERGED CODES

62 Prm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

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TITLE Side 1 of Card 2-2 PAGE 9 OF 12

PROGRAMMER MAGNETICS: 2-D DATE

TI Programmable **Coding Form**

LOC	CODE	KEY	COMMENTS
400	31	31	
401	39	COS	
402	65	×	
403	43	RCL	
404	33	33	
405	23	LNX	
406	54	)	
407	65	×	
408	43	RCL	Calculate F_i'
409	35	35	
410	38	SIN	
411	65	×	
412	43	RCL	
413	36	36	
414	65	×	
415	43	RCL	
416	02	02	
417	65	×	
418	02	2	
419	95	=	
420	94	+/-	
421	44	SUM	
422	32	32	
423	97	DSZ	
424	01	01	End of main loop.
425	97	DSZ	
426	71	SBR	
427	59	INT	
428	04	4	Restore index regs i,j.
429	42	STO	
430	00	00	
431	76	LBL	Σ+:
432	78	Σ+	
433	69	OP	
434	20	20	
435	43	RCL	
436	38	38	
437	74	SM*	Shift origin back to original position.
438	00	00	
439	69	OP	
440	20	20	
441	43	RCL	
442	39	39	
443	74	SM*	
444	00	00	
445	97	DSZ	
446	01	01	
447	78	Σ+	
448	71	SBR	Restore loop reg.
449	59	INT	
450	43	RCL	
451	32	32	Print+display $\Delta T'$
452	99	PRT	
453	98	ADV	
454	91	R/S	
455	43	RCL	
456	30	30	Increment $\Delta\Sigma$ for profile calculations.
457	44	SUM	
458	38	38	
459	43	RCL	
460	38	38	
461	66	PAU	
462	32	X:T	
463	43	RCL	
464	39	39	
465	61	GTO	Restart calc at entry E.
466	15	E	
467	00	0	
468	00	0	
469	00	0	
470	00	0	
471	00	0	
472	00	0	
473	00	0	
474	00	0	
475	00	0	
476	00	0	
477	00	0	
478	00	0	
479	00	0	

MERGED CODES

62 Prm ind | 72 STO ind | 83 GTO ind
63 Exc ind | 73 RCL ind | 84 Op ind
64 Prd ind | 74 SUM ind | 92 INV SBR

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TITLE Side 2 of Card 2-1 PAGE 10 OF 12

PROGRAMMER MAGNETICS: 2-D DATE

TI Programmable **Coding Form**

LOC	CODE	KEY	COMMENTS
240	87	IFF	Start calc for ΔH', ΔV'
241	02	02	
242	79	x̄	
243	02	2	If flag 2 set, get ΔV'
244	03	3	
245	03	3	
246	02	2	
247	03	3	
248	05	5	"HOR."
249	04	4	
250	00	0	
251	61	GTO	
252	22	INV	
253	76	LBL	
254	79	x̄	
255	04	4	
256	02	2	
257	01	1	"VER."
258	07	7	
259	03	3	
260	05	5	
261	04	4	
262	00	0	
263	76	LBL	Inv:
264	22	INV	
265	69	OP	Print
266	01	01	"_ ANOM"
267	69	OP	
268	05	05	
269	69	OP	
270	00	00	
271	04	4	Initialize index j.
272	42	STO	
273	00	00	
274	76	LBL	Sum:
275	44	SUM	
276	69	OP	
277	20	20	
278	43	RCL	
279	38	38	Shift origin to this field point.
280	94	+/-	
281	74	SM*	
282	00	00	
283	69	OP	
284	20	20	
285	43	RCL	
286	39	39	
287	94	+/-	
288	74	SM*	
289	00	00	
290	97	DSZ	
291	01	01	
292	44	SUM	
293	71	SBR	Restore loop reg.
294	59	INT	
295	05	5	Initialize index reg.
296	42	STO	
297	00	00	
298	76	LBL	Dsz: main loop entry
299	97	DSZ	
300	71	SBR	
301	37	P/R	Get D_i
302	01	1	
303	32	X:T	
304	43	RCL	Test if i+1st vertex equals 1st vertex
305	01	01	
306	22	INV	
307	67	EQ	
308	28	LOG	
309	43	RCL	
310	05	05	If so,
311	75	-	
312	73	RC*	Get D_i using 1st vertex as i+1st vertex
313	00	00	
314	95	=	
315	32	X:T	
316	69	OP	
317	20	20	
318	43	RCL	
319	06	06	
320	75	-	
321	73	RC*	
322	00	00	
323	95	=	
324	22	INV	
325	37	P/R	
326	42	STO	
327	35	35	
328	69	OP	
329	30	30	
330	76	LBL	Leg:
331	28	LOG	
332	73	RC*	
333	00	00	Recall coords for calc. of
334	32	X:T	
335	69	OP	
336	20	20	
337	73	RC*	
338	00	00	$\Delta\phi_i$,
339	22	INV	
340	37	P/R	R_{i+1}/R_i
341	42	STO	
342	34	34	
343	32	X:T	
344	35	1/X	
345	42	STO	
346	33	33	
347	69	OP	
348	20	20	
349	01	1	
350	32	X:T	
351	43	RCL	Test if i+1st vertex equals 1st vertex
352	01	01	
353	67	EQ	
354	32	X:T	
355	73	RC*	
356	00	00	
357	32	X:T	
358	69	OP	
359	20	20	
360	73	RC*	
361	00	00	
362	61	GTO	
363	69	OP	
364	76	LBL	x↔t:
365	32	X:T	
366	43	RCL	If so, use x_1, z_1 as i+1st vertex.
367	05	05	
368	32	X:T	
369	43	RCL	
370	06	06	
371	76	LBL	OP:
372	69	OP	
373	22	INV	
374	37	P/R	Get $\Delta\phi_i$, R_{i+1}/R_i
375	22	INV	
376	44	SUM	
377	34	34	
378	32	X:T	
379	49	PRD	
380	33	33	
381	69	OP	
382	30	30	
383	53	(	
384	53	(	
385	43	RCL	Get $I'-D_i$
386	37	37	
387	75	-	
388	43	RCL	
389	35	35	
390	54	)	
391	42	STO	
392	31	31	
393	38	SIN	Convert $\Delta\phi_i$ to radians & mult. by $\sin(I'-D)$
394	65	×	
395	89	π	
396	55	÷	
397	01	1	
398	08	8	
399	00	0	

MERGED CODES

62 Pgm Ind | 72 STO Ind | 83 GTO Ind
63 Exc Ind | 73 RCL Ind | 84 OP Ind
64 Prt Ind | 74 SUM Ind | 92 INV SBR

TEXAS INSTRUMENTS INCORPORATED

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TITLE Side 2 of Card 2-2 PAGE 11 OF 12 TI Programmable Coding Form

PROGRAMMER MAGNETICS: 2-D DATE

LOC	CODE	KEY	COMMENTS
400	65	×	
401	43	RCL	
402	34	34	
403	85	+	
404	43	RCL	
405	31	31	
406	39	COS	
407	65	×	
408	43	RCL	Get F_i'
409	33	33	
410	23	LNX	
411	54	)	
412	65	×	
413	43	RCL	
414	35	35	
415	38	SIN	
416	65	×	
417	43	RCL	
418	36	36	
419	34	ΓX	
420	65	×	
421	43	RCL	
422	02	02	
423	65	×	
424	02	2	
425	95	=	
426	94	+/-	
427	44	SUM	
428	32	32	
429	97	DSZ	End of Main Loop —
430	01	01	
431	97	DSZ	
432	71	SBR	Restore index regs i, j
433	59	INT	
434	04	4	
435	42	STO	
436	00	00	
437	76	LBL	Σ+:
438	78	Σ+	
439	69	OP	
440	20	20	
441	43	RCL	
442	38	38	Shift origin back to initial position
443	74	SM*	
444	00	00	
445	69	OP	
446	20	20	
447	43	RCL	
448	39	39	
449	74	SM*	
450	00	00	
451	97	DSZ	
452	01	01	
453	78	Σ+	
454	71	SBR	

LOC	CODE	KEY	COMMENTS
455	59	INT	Restore loop reg.
456	43	RCL	
457	32	32	
458	99	PRT	Print + display $\Delta F'$
459	98	ADV	
460	91	R/S	
461	43	RCL	
462	30	30	Increment by ΔX for profile calculation.
463	44	SUM	
464	38	38	
465	43	RCL	
466	38	38	
467	66	PAU	
468	32	X:T	
469	43	RCL	
470	39	39	
471	61	GTO	Restart calc. at entry E.
472	15	E	
473	00	0	
474	00	0	
475	00	0	
476	00	0	
477	00	0	
478	00	0	
479	00	0	

LOC	CODE	KEY	COMMENTS

MERGED CODES

62 Prm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

TEXAS INSTRUMENTS INCORPORATED

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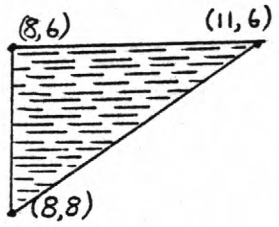
Example: (5,5) (8,5)

Find $\Delta T'$, $\Delta H'$, and $\Delta V'$ at field points $(X,Z)=(5,5)$ and $(8,5)$ due to 2-D triangular body shown. Take $T=50{,}000$ nT, $\kappa=0.001$ emu (i.e., $\kappa T=50$nT), $I=10°$, and $\lambda=60°$.



SOLUTION:

variable	Key		display

- Read Side 1 and Side 2 of Card 1.
- Read Side 1 of Card 2 for $\Delta T'$ field.

κT	50.	A	0.
I	10.	B	0
λ	60.	C	60.
i	1.	2nd D	0.
x_1	8	x↔t	(1.)
z_1	8	D	1.
x_2	8	x↔t	(9.)
z_2	6	D	2.
x_3	11	x↔t	(9.)
z_3	6	D	3.
X	5	x↔t	(9.)
Z	5	E	10.93630999
X	8	x↔t	(45.)
Z	5	E	-12.5458537

- Read Side 2 of Card 2 for $\Delta H'$ field.

X	5.	x↔t	(90.)
Z	5	E	11.14224509
X	8	x↔t	(45.)
Z	5	E	-25.50309898

- Set Flag 2 for $\Delta V'$ field:

	2nd St flg 2		
X	5.	x↔t	(90.)
Z	5	E	8.254850669
X	8	x↔t	(45.)
Z	5	E	53.00911886

1.

Display values enclosed in parentheses have no particular significance, but are given here to help debug new programs.

```
K × FIELD
        50.
FIELD INCLIN.
        10.
STRIKE
        60.
```

```
BODY  PT.     1
        8.
        8.

BODY  PT.     2
        8.
        6.

BODY  PT.     3
        11.
        6.
```

```
FIELD PT.
        5.
        5.
TOT. ANOM
10.93630999

FIELD PT.
        8.
        5.
TOT. ANOM
-12.5458537
```

```
FIELD PT.
        5.
        5.
HOR. ANOM
11.14224509

FIELD PT.
        8.
        5.
HOR. ANOM
-25.50309898
```

```
FIELD PT.
        5.
        5.
VER. ANOM
8.254850669

FIELD PT.
        8.
        5.
VER. ANOM
53.00911886
```