CALIFORNIA STATE BOARD OF REGISTRATION
FOR PROFESSIONAL ENGINEERS

LS C

1982

LAND SURVEYOR

PRINCIPLES AND PRACTICE

1. This examination is given in two four-hour periods on the same day. The subject matter relates to the principles and practice of land surveying. Part "C" is the first of two parts.

2. In the workbook, you are to work ALL Problems C-1 through C-7. There are no optional questions.

3. You may withdraw from scoring any part of your work by isolating that part, and writing "VOID" across it. Delineate the voided part clearly.

4. Enter your identification number in the upper right-hand corner on EACH PAGE of the workbook where space is provided and IDENTIFY THE PROBLEM NUMBER according to the schedule given in (6) below.

5. Read the instructions on the workbook cover page.

6. This portion of the Land Surveyors Examination consists of the following:

Problem C-1	5	Points
Problem C-2	5	Points
Problem C-3	10	Points
Problem C-4	7.5	Points
Problem C-5	7.5	Points
Problem C-6	5	Points
Problem C-7	10	Points
TOTAL	50	Points

YOU ARE TO WORK ALL 7 PROBLEMS

7. After you have completed this portion of the examination, check the problem order, include all pages, and turn it in to the Examination Proctor.

8. You may keep this set of examination questions.

TURN THIS PAGE IMMEDIATELY AND BEGIN YOUR

EXAMINATION

Problem C-2 (5 Points)

REQUIRED

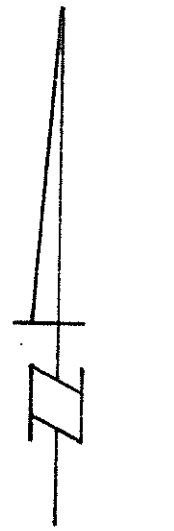
GIVEN:

1. DATA SHOWN ON THIS SHEET. MAKE NO ASSUMPTIONS.
2. SCALE FACTOR = 0.9999612.
3. REDUCTION FACTOR = 0.99997608. (To SEA LEVEL)
4. ALL DISTANCES SHOWN ARE GROUND DISTANCES.
5. ALL BEARINGS SHOWN ARE GRID BEARINGS.

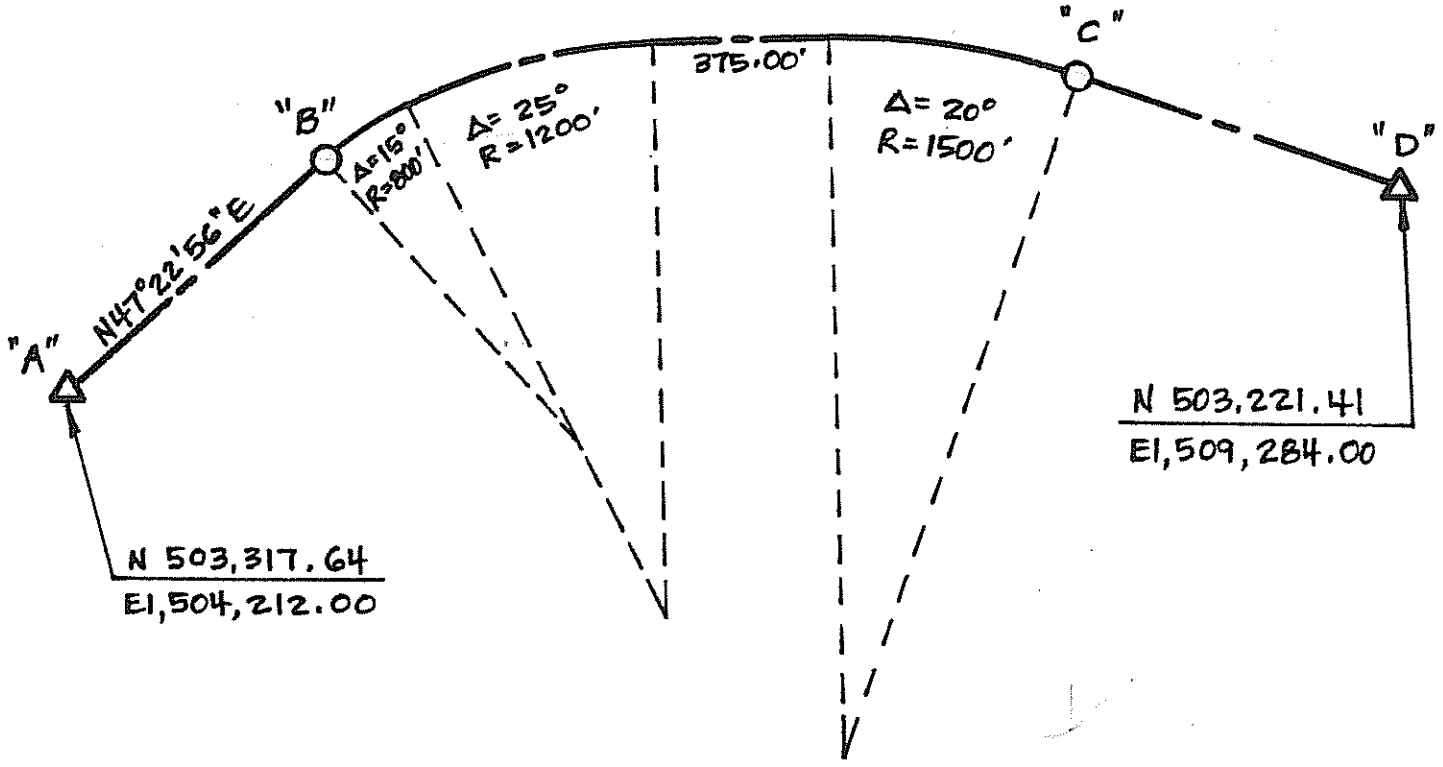
SOLVE, TO THE NEAREST HUNDREDTH, FOR:

1. GROUND DISTANCE A-B.
2. GROUND DISTANCE C-D.
3. LAMBERT COORDINATES FOR POINT B.
4. LAMBERT COORDINATES FOR POINT C.

YOU MUST SHOW ALL WORK



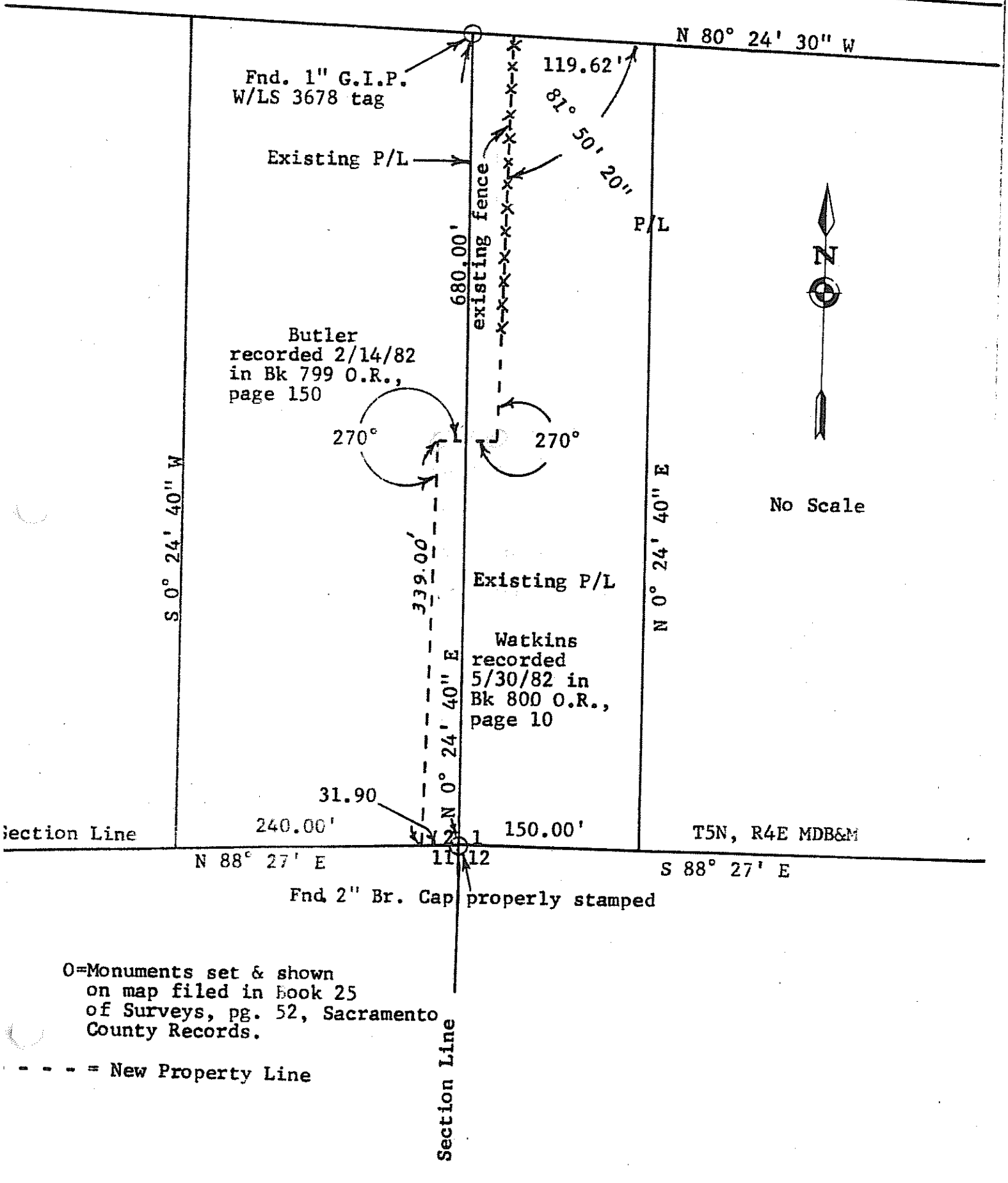
NOT TO SCALE



NOTE: ALL CURVES ARE TANGENT.

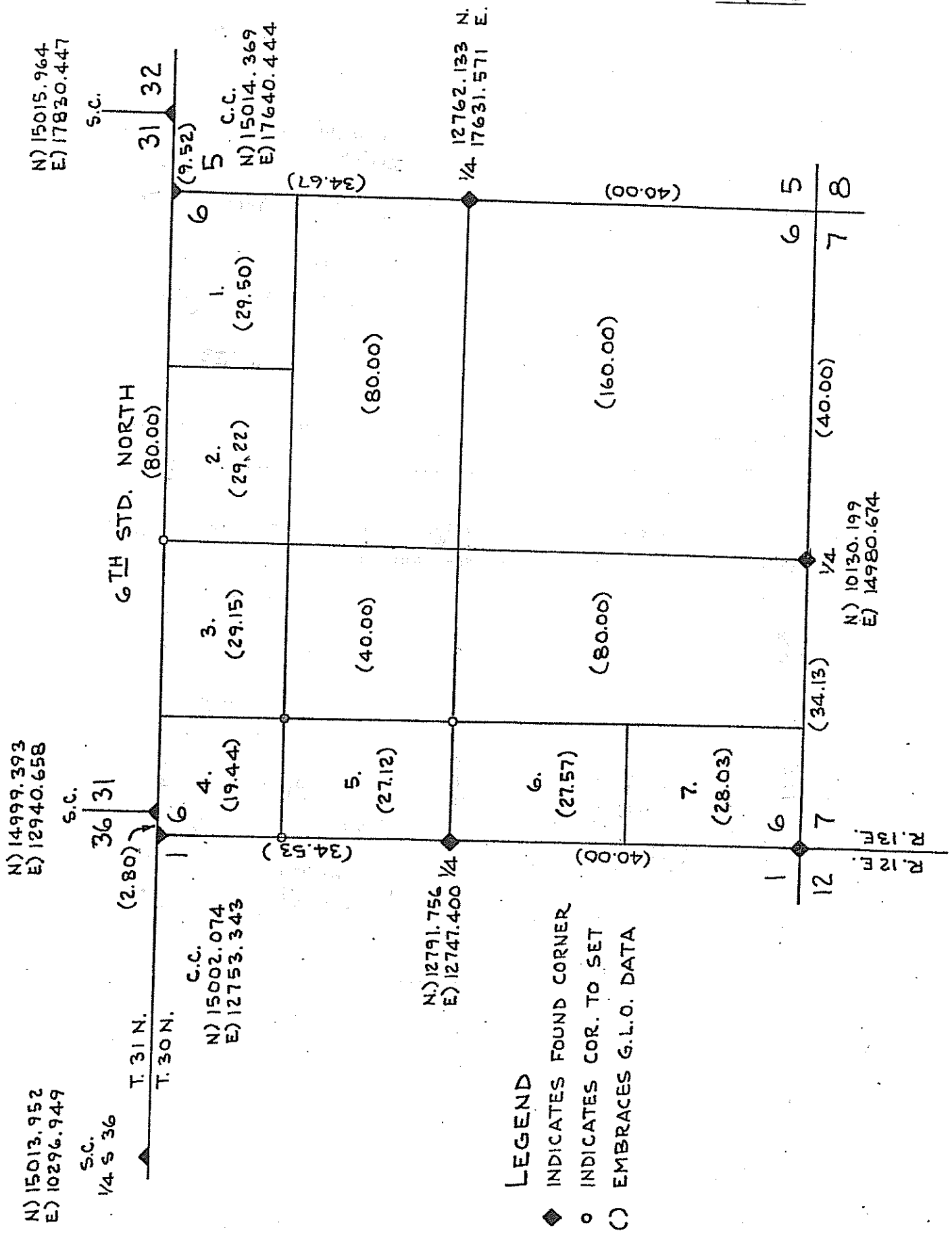
Problem C-3 (10 Points)

REQUIRED



Problem C-4 (7.5 Points)

REQUIRED



LEGEND

◆ INDICATES FOUND CORNER

o INDICATES COR. TO SET

( ) EMBRACES G.L.O. DATA

Problem C-5 (7.5 Points) REQUIRED

9. The county recorder shall not have more than ___ _____ within which to examine a final or parcel map and either _____ or _____ it for filing.

10. A _____ corner determines the direction of a line, not necessarily its terminus. (public lands)

11. Monuments called for in a deed, either directly or by reference to a plat which the parties acted by are subordinate to _____ rights, but are superior to _____, _____ and _____.

12. The filing for record of a final or parcel map by the county recorder shall automatically and finally determine the validity of such map and when recorded shall impart _____ notice thereof.

13. Every licensed land surveyor or registered civil engineer may administer and certify _____ when it becomes necessary to take testimony for the identification and establishment of ____ or _____ corners.

14. Excess or deficiency occuring within a block should not be _____ among other blocks.

15. When the end lot measurement is not given, all the excess or deficiency is presumed to be given to ___ ___ ___.

16. Proportionate measurement can not be used to alter an acceptable original _____ position.

17. An approved or conditionally approved tentative map shall expire ____ _____ after its approval or conditional approval or after such additional period of time as may be prescribed by local ordinance, not exceed an additional ___ _____ .

Problem C-6 (5 Points)

REQUIRED

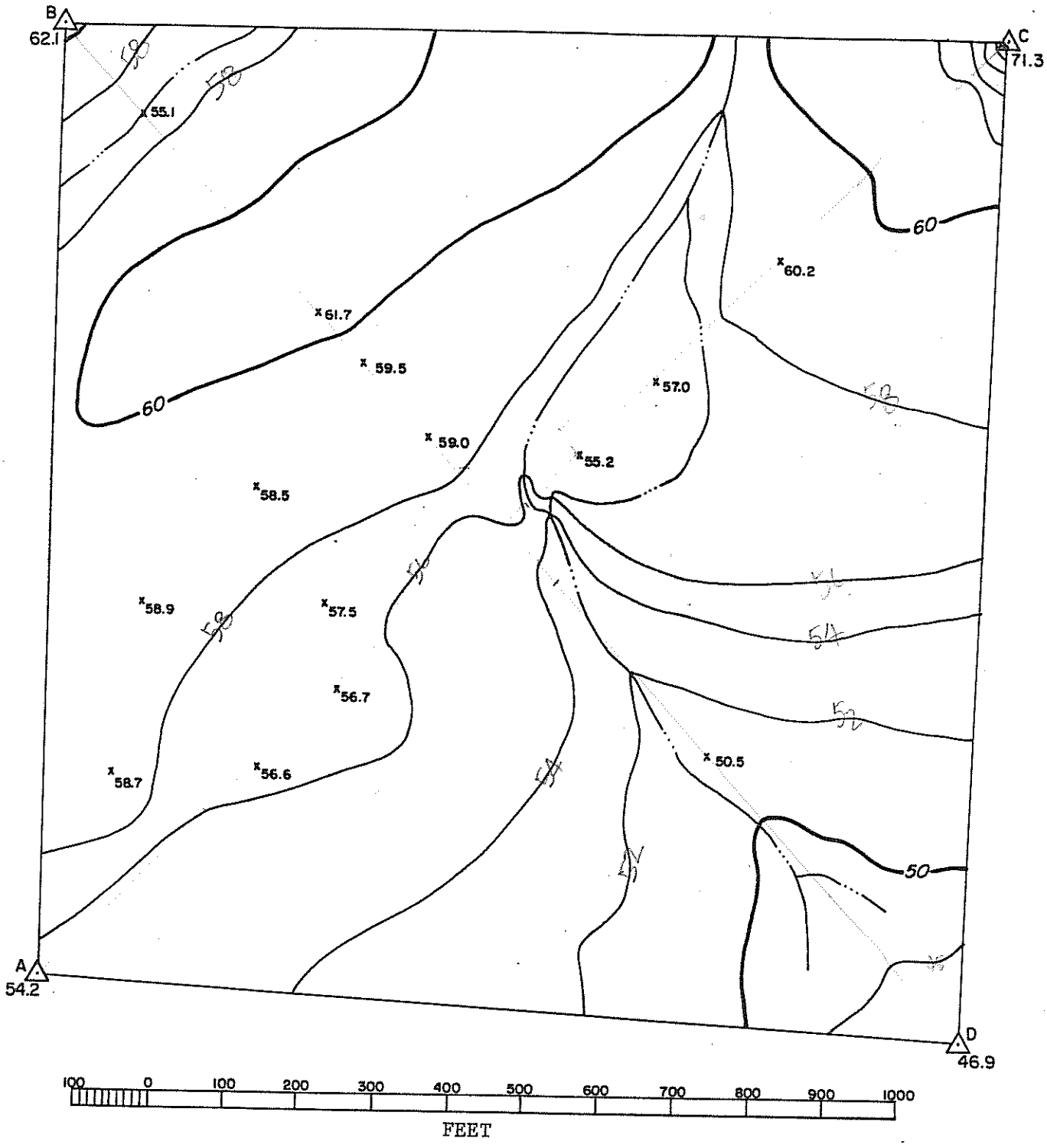
A) Give five examples of current State and National problems being discussed in the surveying profession:

B) Give seven examples of criteria generally discussed as a requirement in being a Professional Land Surveyor:

C) List five periodical publications available to Land Surveyors, which relate directly to land surveying in the nation and State of California.

Problem C-7 (10 Points)

REQUIRED



CALIFORNIA STATE BOARD OF REGISTRATION
FOR PROFESSIONAL ENGINEERS

L.S D

1982

LAND SURVEYOR

PRINCIPLES AND PRACTICE

1. This part of the examination - "Part D" - is the second part of the Land Surveyor examination, and is to be completed in 4 hours.

2. Your answers are to be completed in your workbook - use <u>separate answer sheets for each problem</u>, unless otherwise instructed.

3. This portion of the Land Surveyor examination consists of the following:

Problem D-1	REQUIRED	10.0 Points
Problem D-2 <u>OR</u> Problem D-3	CHOOSE ONE	10.0 Points
Problem D-4 <u>OR</u> Problem D-5	CHOOSE ONE	5.0 Points
Problem D-6	REQUIRED	5.0 Points
Problem D-7	REQUIRED	10.0 Points
Problem D-8	REQUIRED	5.0 Points
Problem D-9	REQUIRED	5.0 Points
	TOTAL	50.0 Points

4. Do <u>not</u> work both problems where a choice is offered. Credit will be allowed for one (1) problem only.

5. Problem D-3 requires that you remove one sheet that is to be attached to your workbook.

6. After you have completed this portion of the examination, check the problem order, include all pages (including diagrams if required) and turn it in to the examination proctor.

7. You may keep this set of examination questions.

Problem D-1 (10 Points)

REQUIRED

Radio Station KPLN is installing a new radio tower.and is required to give the F.C.C. the geographic position (to the nearest 10") of the tower. You have been asked to establish the position of the tower; to do this you will set on control point "Green" , back-sight control point "Red" and tie in the radio tower. The data gathered is as follows:

"Green" : State Plane Coordinates (zone IV) x=1,453,181.23 y=11,287.00; Elevation = 1850' Geodetic Azimuth to "Red" (north) = 358°22'59".9

Field angle (right) to radio tower 210°15'04"

Horizontal ground distance to radio tower = 10,368.074'

radio tower elevation = 2250'

What is the latitude and longitude of the radio tower ?

Constants	IV	V
C	2,000,000	2,000,000
Central Meridian	119° 00'	118° 00'
R_b	28,652,931.96	30,649,424.27
y_o	470,526.63	455,278.73
ℓ	0.59658 71443	0.57001 19219
$\frac{1}{2\rho_o^2 \sin 1''}$	2.360×10^{-10}	2.361×10^{-10}
$\log \frac{1}{2\rho_o^2 \sin 1''}$	0.372 8843 - 10	0.373 0670 - 10
$\log \ell$	9.77567 38907 - 10	9.75588 39391 - 10
log k	7.62714 43424	7.63926 75454

Mean radius of the Earth = 20,906,000

Lambert Projection for California V

Table I (Cont'd)

Problem D-1 (10 Points)

REQUIRED

Lat.	R feet	Y' y value on central meridian feet	Tabular difference for 1 sec. of lat.	Scale in units of 7th place of logs	Scale expressed as a ratio
35° 16'	30,006,492.15	642,932.12	101.10317	-162.8	0.9999625
17	30,000,425.96	648,998.31	101.10367	-151.2	0.9999652
18	29,994,359.74	655,064.53	101.10417	-139.3	0.9999679
19	29,988,293.49	661,130.78	101.10483	-127.0	0.9999708
20	29,982,227.20	667,197.07	101.10533	-114.4	0.9999737
35° 21'	29,976,160.88	673,263.39	101.10600	-101.4	0.9999767
22	29,970,094.52	679,329.75	101.10667	-88.0	0.9999797
23	29,964,028.12	685,396.15	101.10717	-74.3	0.9999829
24	29,957,961.69	691,462.58	101.10783	-60.2	0.9999861
25	29,951,895.22	697,529.05	101.10833	-45.7	0.9999895
35° 26'	29,945,828.72	703,595.55	101.10900	-30.8	0.9999929
27	29,939,762.18	709,662.09	101.10983	-15.6	0.9999964
28	29,933,695.59	715,728.68	101.11033	0.0	1.0000000
29	29,927,628.97	721,795.30	101.11100	+16.0	1.0000037
30	29,921,562.31	727,861.96	101.11167	+32.3	1.0000074
35° 31'	29,915,495.61	733,928.66	101.11233	+49.0	1.0000113
32	29,909,428.87	739,995.40	101.11300	+66.0	1.0000152
33	29,903,362.09	746,062.18	101.11383	+83.5	1.0000192
34	29,897,295.26	752,129.01	101.11433	+101.3	1.0000233
35	29,891,228.40	758,195.87	101.11517	+119.5	1.0000275

Table II (Cont'd)

1" of Long. = 0".57001192 of θ

Long.	θ	Long.	θ	Long.	θ
119° 36'	-0° 54' 43".2687	120° 11'	-1° 14' 40".2937	120° 46'	-1° 34' 37".3187
37	-0 55 17.4694	12	-1 15 14.4944	47	-1 35 11.5195
38	-0 55 51.6701	13	-1 15 48.6951	48	-1 35 45.7202
39	-0 56 25.8708	14	-1 16 22.8959	49	-1 36 19.9209
40	-0 57 00.0715	15	-1 16 57.0966	50	-1 36 54.1216
119° 41'	-0 57 34.2722	120° 16'	-1 17 31.2973	120° 51'	-1 37 28.3223
42	-0 58 08.4730	17	-1 18 05.4980	52	-1 38 02.5230
43	-0 58 42.6737	18	-1 18 39.6987	53	-1 38 36.7237
44	-0 59 16.8744	19	-1 19 13.8994	54	-1 39 10.9245
45	-0 59 51.0751	20	-1 19 48.1001	55	-1 39 45.1252
119° 46'	-1 00 25.2758	120° 21'	-1 20 22.3009	120° 56'	-1 40 19.3259
47	-1 00 59.4765	22	-1 20 56.5016	57	-1 40 53.5266
48	-1 01 33.6773	23	-1 21 30.7023	58	-1 41 27.7273
49	-1 02 07.8780	24	-1 22 04.9030	59	-1 42 01.9280
50	-1 02 42.0787	25	-1 22 39.1037	121° 00'	-1 42 36.1284

Problem D-2 (10 Points) OPTIONAL

In setting out aerial control you decide to establish the vertical control by trigonometric leveling. Below is the reduced data for the control. The aerial survey is for a topographic map with a 5 foot contour interval. Establish the unadjusted elevations for the control points; determine if the data should be adjusted and if so perform an adjusment explaining your reasons for the adjustment, if no adjustment is required explain why.

Point	HI	Horizontal Dist.	Vertical Angle	Elevation
A	5.20			1123.05
		8,323.25	+0°49'16"	
B	5.49			
		5,529.64	+0°31'03"	
C	5.15			
		10,436.78	-0°29'32"	
D	5.38			
		4,991.67	-0°18'40"	
E	5.72			
		3,875.11	-0°48'57"	
A	5.20			1123.05

(HI indicates height for both instrument and sight)

YOU MUST SHOW ALL WORK

I.D. NO. _____

Problem D-3 (10 Points)

OPTIONAL

ANGLE	MEAN VALUE	STD ERROR	WEIGHT	CORRECTED ANGLE	FAIL	PASS
A						
B1						
B2						
C1						
C2						
D						
E1						
E2						
E3						

NOTE: REMOVE THIS PAGE FROM BOOKLET AND TURN IN WITH YOUR ANSWERS.

ENTER YOUR I.D. NO. IN SPACE PROVIDED ABOVE

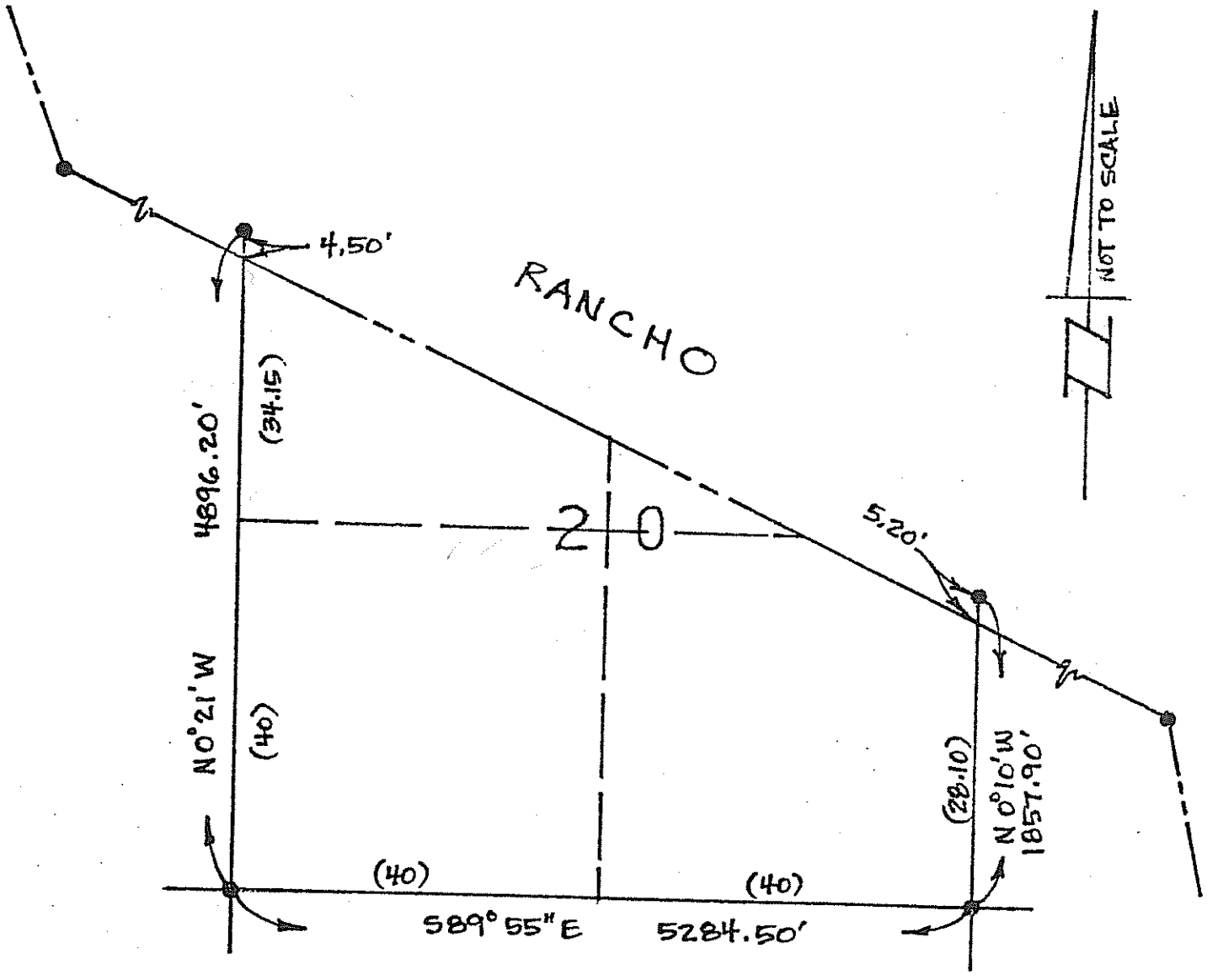
Problem D-4 (5 Points)

OPTIONAL

The plat shown below shows fractional Section 20. The meridian and range are not identified. The bearings and distances given in feet are the results of your survey. The information in parentheses is record per the Government Plat.

REQUIRED:

Compute the courses for the SW ¼ of Section 20. Explain briefly the steps in the procedure you have followed in your solution.



● Denotes found original corner

Problem D-5 (5 Points) OPTIONAL

No. 2 Wt. 0.5 When it is required that targets be placed close to trees, the surveyor needs to be concerned with:

a) Only with the potential of hiding the target with tree shadows.

b) That the targets should never be placed within a horizontal distance less than the heighth of the trees adjoining.

c) Only, that either shadows or photo displacement of tall trees in the outer edges of the stereo model might hide the target.

No. 3 Wt. 0.5 Choose one answer from the following target visibility considerations; in the correct order of their photogrammetric importance:

a) Length of target legs, width of legs, contrast, and number of legs of the target.

b) Width of legs, number of legs, contrast, and length of legs.

c) Contrast, length of legs, width of legs, number of legs.

No. 4 Wt. 0.5 Target size: In order to clearly identify targets, the overall target length and the leg width expressed as a measurement in feet of a portion of the photo scale is used as a criteria. The correct answer is the minimum size of the choices below considering the 5 diameter magnification of the projection type "Kelsh" plotter and the photo scale of 1" to 240'.

a) Target leg 0.01" for length; 0.002" for leg width of the photo scale.

Problem D-5 (5 Points)

OPTIONAL

c) Control density requires a minimum of three vertical and two horizontal points per stereo model. Four vertical points and three horizontal points provide a check in each model. Consistent with survey economy, widespread control is generally the best answer regardless of the width of the mapping strip.

No. 7 Wt. 0.5 Accuracy of horizontal control: In terms of economics the surveyor will choose one of the following position closures as a working guide in providing large scale mapping control. The criteria is 1" to 40' final scale mapping, assuming a mapping strip of approximately two miles.

a) 1:50,000

b) 1:36,000

c) 1:10,000

d) 1:5,000

e) 1:3,000

No. 8 Wt. 0.5 One of the following statements regarding vertical control points is most correct. The prudent surveyor will:

a) Always loop levels and give elevation data to the top of monument at the target.

b) In addition to "a)", he will furnish a sketch of the target.

c) He will loop levels, give elevation to the top of monument, sketch and determine elevation of the top of target panel if it is different than the monument at the target.

d) He will perform all of the above in "c)" and take two views in polaroid color of the target in every case.

Problem D-6 (5 Points) REQUIRED

PUBLIC LAND LAWS

1.) Where does one find the authority for the Public Land Laws?

2.) Where does one find the authority for, and range of powers of, the Bureau of Land Management?

3.) If you are contracted by the Bureau of Land Management to perform a boundary survey of Public Lands, do you need to be a Licensed Land Surveyor? (of which state?) Cite authority for your answer.

4.) Where does one find that the township is the basis of subdividing the Public Lands?

5.) Is it possible for the U. S. Government to re-survey an entire township in which over 50% of the land is in private ownership, re-setting all section corners and make or have the new corners control over the originals?

A PORTION OF

WATERSIDE TERRACE

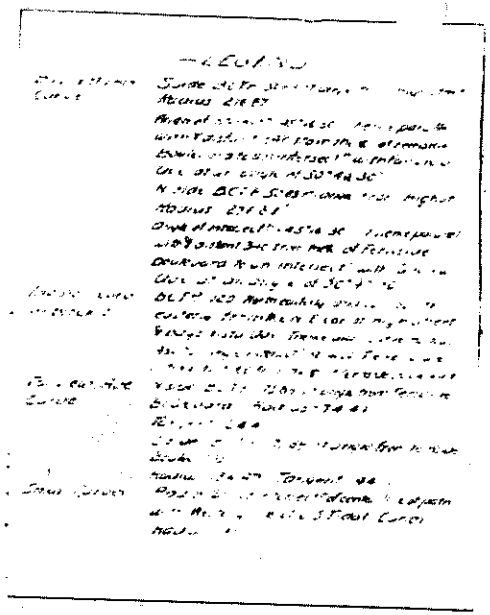
ALAMEDA, CAL.

1912

Scale 60 Feet = 1 Inch

Problem D-7 (10 Points)

LS-D
1982
Page 17



(See over for enlargement of "LEGEND")

NORTHERLY
1" = 60'

BLOCK 'B'

BAYO VISTA AVENUE (60' Right of Way)

REQUIRED

HIGH STREET (60' Right of Way)

LOT 6	LOT 7	LOT 8	LOT 9	LOT 10	LOT 11	LOT 12	LOT 13	LOT 14
120	40	40	40	40	40	40	40	165.06

74.47

FAIRVIEW AVENUE (60' Right of Way)

Problem D-8 (5 Points)

REQUIRED

The Subdivision Map Act was originally a part of the Business and Professions Code until it was recodified into the Government Code in March of 1975. Answer the parts of this question according to the current Government Code of the Subdivision Map Act.

A. What is a subdivision?

B. Name two examples where a Parcel Map is required instead of a tentative and final Subdivision Map?

C. When a Parcel Map is required, the surveyor shall base the map upon a field survey made in conformity with the Land Surveryor's Act. What is another method allowed of indicating the boundaries of a Parcel Map?

D. After a final map or parcel map is filed in the office of the County Recorder, what are the reasons that would cause it to be amended by certificate of correction or amending map?

E. Describe the procedure for setting monuments for a subdivision on which the original engineer or surveyor has died?

F. Name the types of improvement security allowed by the Subdivision Map Act?

G. Name three types of offers of dedication within the Subdivision which may be imposed by local ordinance?

Problem D-9 (5 Points)

REQUIRED

POLARIS AT ANY TIME

27. **Example.** Time of observation May 5, 1982; watch reading, 8:28:23 PM, 90th Meridian time; watch known to be 0:02:03 slow; latitude (from map) N42° 22.6′; longitude (from map) W92° 58.3′; clockwise angle, mark to star 25° 53.0′.

Find the *LHA* and *t* (see Sec. 14) as shown below.

Watch time		8:28:23 PM
Watch correction (slow is plus)		2:03 slow
Standard time (90th meridian)		8:30:26 PM
Correction to 24 hour basis	+	12
90th meridian time		20:30:26
Correction for time zone	+	6
GCT (Sec. 5)		26:30:26
GCT May 6, 1982		2:30:26
GHA (Sec. 2) 0^h May 6, 1982 Table 1		190° 27.3′
Correction for 2^h 30^m (Table 5)	+	37 36.2
Correction for 26^s (Table 5)	+	6.5
GHA		228° 10.0′
Less west longitude (from map)		− 92° 58.3′
LHA (Sec. 14)		135° 11.7′
t = *LHA* or 360 − *LHA* (use smaller)		135° 11.7′

CELESTIAL OBSERVATIONS

28. **Computation.** The bearing of Polaris (*Z*) (Sec. 15) is found from the formula:

$$Z = \frac{\sin t}{\cos h}\, p \quad \ldots\ldots\ldots\ldots (5)$$

where

t (Sec. 14) is the meridian angle just computed above.

h (Sec.20) is the true altitude. It is usually obtained from the known latitude *l*, using Table 6, and then it need not be observed.

p (Sec. 17) is the polar distance.

Four optional procedures for the computation are given below. Procedure A is the solution which is familiar to K&E Solar Ephemeris users. Procedures B, C and D are added to give a more precise solution under different conditions of latitude and instrumentation.

Procedure A

Table 10 gives values of *Z* for selected values of *LHA* and *l* when *p*=0° 49.00′. By a two-way interpolation the value of *Z* can be found from the known values of *LHA* and *l*. Table 11 gives the correction to be applied for values of *p* other than 0° 49.00′.

Example.

LHA =	*l* = 42°	42° 22.6′	44°
135°	46.2′	46.5′	47.7′
135° 11.7′		46.3′	
140°	42.0′	42.2′	43.3′

Problem D-9 (5 Points)

REQUIRED

TABLE 2a

To correct Table 2. See Examples below.

MULTIPLIERS FOR OBSERVED BAROMETRIC PRESSURE OR ELEVATION

Bar. (Inches)	Elev. (Feet)	Multiplier	Bar. (Inches)	Elev. (Feet)	Multiplier
30.5	− 451	1.03	23.9	+ 6104	0.81
30.2	− 181	1.02	23.6	6538	0.80
30.0	00	1.01	23.3	6887	0.79
			23.0	7239	0.78
29.9	+ 91	1.01			
29.6	366	1.00	22.7	7507	0.77
29.3	643	0.99	22.4	7960	0.76
29.0	924	0.98	22.1	8327	0.75
28.7	1207	0.97	21.8	8700	0.74
28.4	1493	0.96	21.5	9077	0.73
28.1	1783	0.95	21.2	9460	0.72
27.8	2075	0.94	20.9	9848	0.71
27.5	2371	0.93	20.6	10242	0.70
27.2	2670	0.92	20.3	10642	0.69
			20.0	11047	0.68
26.9	2972	0.91			
26.6	3277	0.90	19.7	11468	0.67
26.3	3586	0.89	19.4	11876	0.66
26.0	3899	0.88	19.1	12299	0.65
25.7	4215	0.87	18.8	12729	0.64
25.4	4535	0.86	18.5	13165	0.63
25.1	4859	0.85	18.2	13608	0.62
24.8	5186	0.84	17.9	14058	0.61
24.5	5518	0.83			
24.2	5854	0.82			

MULTIPLIERS FOR TEMPERATURE

Temp. Deg. F	Multiplier	Temp. Deg. F	Multiplier	Temp. Deg. F	Multiplier
− 20	1.16	+ 30	1.04	+ 80	0.94
− 10	1.13	+ 40	1.02	+ 90	0.93
0	1.11	+ 50	1.00	+100	0.91
+ 10	1.08	+ 60	0.98	+110	0.90
+ 20	1.06	+ 70	0.96	+120	0.88

Example. Sun: Meas. Alt. = 30°; Bar. = 26 in. or Elev. 3900 ft.; Temp. 70° F.
Refraction = 1.66′ (0.88) (0.96) = 1.40′. Parallax = 0.13′.
True Alt. = 30° 00.00′ − 1.40′ + 0.13′ = 29° 58.73′.

Example. Star: Meas. Alt. = 25°; Bar. = 24.5 or Elev. 5518 ft.; Temp. 10° F.
Refraction = 2.05′ (0.83) (1.08) = 1.84′.
True Alt. = 25° 00.00′ − 1.84′ = 24° 58.16′.

TABLE 3

POLAR DISTANCE OF POLARIS, 1982

For 0h Universal Time or Greenwich Civil Time

1982	Polar Distance Angle	Cotan	1982	Polar Distance Angle	Cotan
	° ′			° ′	
Jan. 1	0 48.85	70.37	July 10	0 49.32	69.76
11	0 48.82	70.41	20	0 49.32	69.76
21	0 48.80	70.44	30	0 49.31	69.71
31	0 48.80	70.44			
			Aug. 9	0 49.29	69.74
Feb. 10	0 48.80	70.44	19	0 49.26	69.78
20	0 48.82	70.41	29	0 49.23	69.83
Mar. 2	0 48.85	70.37	Sep. 8	0 49.18	69.90
12	0 48.88	70.33	18	0 49.13	69.97
22	0 48.92	70.27	28	0 49.08	70.04
Apr. 1	0 48.97	70.20	Oct. 8	0 49.02	70.12
11	0 49.02	70.12	18	0 48.96	70.21
21	0 49.07	70.05	28	0 48.90	70.30
May 1	0 49.12	69.98	Nov. 7	0 48.83	70.40
11	0 49.17	69.91	17	0 48.77	70.48
21	0 49.21	69.85	27	0 48.71	70.57
31	0 49.25	69.80			
			Dec. 7	0 48.66	70.64
June 10	0 49.28	69.75	17	0 48.61	70.72
20	0 49.30	69.73	27	0 48.57	70.77
30	0 49.32	69.70			

Declination = 90° − Polar Distance

TABLE 4

THE SUN'S SEMI-DIAMETER, 1982

For 0h Universal Time or Greenwich Civil Time

Date	Semi-Diam.	Date	Semi-Diam.	Date	Semi-Diam.
1982		1982		1982	
Jan. 1	16.29	May 1	15.90	Sept. 8	15.90
11	16.29	11	15.86	18	15.94
21	16.28	21	15.83	28	15.99
31	16.26	31	15.80		
Feb. 10	16.23	June 10	15.78	Oct. 8	16.03
20	16.20	20	15.76	18	16.08
		30	15.76	28	16.12
Mar. 2	16.16	July 10	15.76	Nov. 7	16.16
12	16.12	20	15.76	17	16.20
22	16.08	30	15.78	27	16.24
Apr. 1	16.03	Aug. 9	15.80	Dec. 7	16.26
11	15.99	19	15.83	17	16.28
21	15.94	29	15.86	27	16.29

Problem D-9 (5 Points)

REQUIRED

TABLE 5
Increase in GHA for Elapsed Time.

Min.	Hours of Greenwich Civil Time 0h		1h		2h		3h	
	°	′	°	′	°	′	°	′
0	0	0.0	15	2.6	30	4.9	45	7.4
1	0	15.0	15	17.6	30	19.9	45	22.4
2	0	30.1	15	32.6	30	35.0	45	37.5
3	0	45.1	15	47.6	30	50.1	45	52.6
4	1	0.2	16	2.6	31	5.1	46	7.6
5	1	15.2	16	17.7	31	20.1	46	22.6
6	1	30.2	16	32.7	31	35.2	46	37.6
7	1	45.3	16	47.8	31	50.2	46	52.7
8	2	0.3	17	2.8	32	5.3	47	7.7
9	2	15.4	17	17.8	32	20.3	47	22.8
10	2	30.4	17	32.9	32	35.3	47	37.8
11	2	45.5	17	47.9	32	50.4	47	52.8
12	3	0.5	18	3.0	33	5.4	48	7.9
13	3	15.6	18	18.0	33	20.5	48	22.9
14	3	30.6	18	33.0	33	35.6	48	38.0
15	3	45.6	18	48.1	33	50.6	48	53.0
16	4	0.7	19	3.1	34	5.6	49	8.0
17	4	15.7	19	18.2	34	20.6	49	23.1
18	4	30.7	19	33.2	34	35.7	49	38.1
19	4	45.8	19	48.2	34	50.7	49	53.2
20	5	0.8	20	3.3	35	5.7	50	8.2
21	5	15.9	20	18.3	35	20.8	50	23.3
22	5	30.9	20	33.4	35	35.8	50	38.3
23	5	45.9	20	48.4	35	50.9	50	53.3
24	6	1.0	21	3.4	36	5.9	51	8.4
25	6	16.0	21	18.5	36	21.0	51	23.4
26	6	31.1	21	33.6	36	36.0	51	38.6
27	6	46.1	21	48.6	36	51.0	51	53.6
28	7	1.1	22	3.6	37	6.1	52	8.6
29	7	16.2	22	18.7	37	21.1	52	23.6
30	7	31.2	22	33.7	37	36.2	52	38.6
31	7	46.3	22	48.7	37	51.2	52	53.7
32	8	1.3	23	3.8	38	6.2	53	8.7
33	8	16.4	23	18.8	38	21.3	53	23.7
34	8	31.4	23	33.9	38	36.3	53	38.8
35	8	46.4	23	48.9	38	51.4	53	53.8
36	9	1.5	24	3.9	39	6.4	54	8.9
37	9	16.5	24	19.0	39	21.4	54	23.9
38	9	31.6	24	34.0	39	36.5	54	39.0
39	9	46.6	24	49.1	39	51.5	54	54.0
40	10	1.6	25	4.1	40	6.6	55	9.0
41	10	16.7	25	19.1	40	21.6	55	24.1
42	10	31.7	25	34.2	40	36.7	55	39.1
43	10	46.8	25	49.2	40	51.7	55	54.2
44	11	1.8	26	4.3	41	6.7	56	9.2
45	11	16.8	26	19.3	41	21.8	56	24.2
46	11	31.9	26	34.4	41	36.8	56	39.3
47	11	46.9	26	49.4	41	51.9	56	54.3
48	12	2.0	27	4.4	42	6.9	57	9.4
49	12	17.0	27	19.5	42	21.9	57	24.4
50	12	32.1	27	34.5	42	37.0	57	39.4
51	12	47.1	27	49.6	42	52.0	57	54.5
52	13	2.1	28	4.6	43	7.1	58	9.5
53	13	17.2	28	19.6	43	22.1	58	24.6
54	13	32.2	28	34.7	43	37.1	58	39.6
55	13	47.3	28	49.7	43	52.2	58	54.6
56	14	2.3	29	4.8	44	7.2	59	9.7
57	14	17.3	29	19.8	44	22.3	59	24.7
58	14	32.4	29	34.8	44	37.3	59	39.8
59	14	47.4	29	49.9	44	52.4	59	54.8
60	15	2.5	30	4.9	45	7.4	60	9.9

Sec.	Corr.
	′
0	0.0
1	0.3
2	0.5
3	0.8
4	1.0
5	1.3
6	1.5
7	1.8
8	2.0
9	2.3
10	2.5
11	2.8
12	3.0
13	3.3
14	3.5
15	3.8
16	4.0
17	4.3
18	4.5
19	4.8
20	5.0
21	5.3
22	5.5
23	5.8
24	6.0
25	6.3
26	6.5
27	6.8
28	7.0
29	7.3
30	7.5
31	7.8
32	8.0
33	8.3
34	8.5
35	8.8
36	9.0
37	9.3
38	9.5
39	9.8
40	10.0
41	10.3
42	10.5
43	10.8
44	11.0
45	11.3
46	11.5
47	11.8
48	12.0
49	12.3
50	12.5
51	12.8
52	13.0
53	13.3
54	13.5
55	13.8
56	14.0
57	14.3
58	14.5
59	14.8
60	15.0

TABLE 5—(Continued)
Increase in GHA for Elapsed Time.

Min	Hours of Greenwich Civil Time 6h		7h		8h		9h	
	°	′	°	′	°	′	°	′
0	90	9.9	105	12.3	120	14.8	135	17.2
1	90	24.9	105	27.4	120	29.8	135	32.2
2	90	39.9	105	42.4	120	44.9	135	47.3
3	90	55.0	105	57.4	120	59.9	136	2.4
4	91	10.0	106	12.5	121	14.9	136	17.4
5	91	25.1	106	27.5	121	30.0	136	32.5
6	91	40.1	106	42.6	121	45.0	136	47.5
7	91	55.1	106	57.6	121	60.0	136	62.4
8	92	10.2	107	12.6	122	5.0	137	7.6
9	92	25.2	107	27.7	122	20.0	137	22.5
10	92	40.3	107	42.7	122	35.1	137	37.6
11	92	55.3	107	57.7	122	50.1	137	52.6
12	93	10.3	108	12.7	123	5.2	138	7.6
13	93	25.4	108	27.7	123	20.2	138	22.7
14	93	40.4	108	42.8	123	35.2	138	37.7
15	93	55.5	108	57.8	123	50.3	138	52.8
16	94	10.5	109	12.9	124	5.3	139	7.8
17	94	25.6	109	27.9	124	20.4	139	22.8
18	94	40.6	109	42.9	124	35.4	139	37.9
19	94	55.6	109	58.0	124	50.4	139	52.9
20	95	10.7	110	13.0	125	5.5	140	8.0
21	95	25.7	110	28.1	125	20.6	140	23.0
22	95	40.8	110	43.1	125	35.6	140	38.0
23	95	55.8	110	58.2	125	50.6	140	53.1
24	96	10.8	111	13.2	126	5.7	141	8.1
25	96	25.9	111	28.3	126	20.7	141	23.2
26	96	40.9	111	43.4	126	35.7	141	38.2
27	96	56.0	111	58.4	126	50.8	141	53.2
28	97	11.0	112	13.5	127	5.8	142	8.3
29	97	26.0	112	28.5	127	20.9	142	23.3
30	97	41.1	112	43.6	127	35.9	142	38.4
31	97	56.1	112	58.6	127	50.9	142	53.4
32	98	11.2	113	13.6	128	6.0	143	8.4
33	98	26.2	113	28.7	128	21.0	143	23.5
34	98	41.2	113	43.7	128	36.1	143	38.5
35	98	56.3	113	58.8	128	51.1	143	53.6
36	99	11.3	114	13.8	129	6.1	144	8.6
37	99	26.4	114	28.8	129	21.2	144	23.7
38	99	41.4	114	43.9	129	36.2	144	38.7
39	99	56.5	114	58.9	129	51.3	144	53.7
40	100	11.5	115	13.9	130	6.3	145	8.8
41	100	26.6	115	28.9	130	21.4	145	23.8
42	100	41.6	115	44.0	130	36.4	145	38.9
43	100	56.6	115	59.1	130	51.4	145	53.9
44	101	11.7	116	14.1	131	6.6	146	8.9
45	101	26.7	116	29.2	131	21.6	146	24.0
46	101	41.7	116	44.2	131	36.6	146	39.0
47	101	56.8	116	59.2	131	51.6	146	54.1
48	102	11.8	117	14.3	132	6.6	147	9.1
49	102	26.9	117	29.3	132	21.7	147	24.1
50	102	41.9	117	44.4	132	36.7	147	39.2
51	102	56.9	117	59.4	132	51.8	147	54.2
52	103	12.0	118	14.5	133	6.8	148	9.3
53	103	27.0	118	29.5	133	21.8	148	24.3
54	103	42.1	118	44.6	133	36.9	148	39.3
55	103	57.1	118	59.6	133	51.9	148	54.4
56	104	12.2	119	14.6	134	7.0	149	9.4
57	104	27.2	119	29.7	134	22.0	149	24.5
58	104	42.2	119	44.7	134	37.0	149	39.5
59	104	57.3	119	59.7	134	52.1	149	54.6
60	105	12.3	120	14.8	135	17.2	150	9.6