True or False

T 1. A measurement set can be accurate without being precise.

F 2. Balancing backsight and foresight distances in leveling is done so random errors will cancel.

T 3. Random errors can be minimized by repeating measurements.

F 4. Systematic errors can be minimized by repeating measurements.

F 5. Standard deviation is an indicator of a measurement set's accuracy

F 6. A mistaken measurement can be included as long as enough additional measurements are made to offset it.

T 7. Earth curvature causes a level rod reading to be too high.

F 8. Systematic errors are always caused by instrument maladjustment.

F 9. A mistake can be included in a least squares adjustment because its effect will be minimized.

T 10. A precise set of measurements that is inaccurate indicates the presence of an unresolved systematic error.

Choice

Indicate whether the following are Random or Systematic errors

S 1. Refraction.

R 2. Manually centering a plumb bob.

S 3. Rotated crosshairs in a level.

R 4. Instrument centering over a ground point.

S 5. Bubble run.

R 6. Manufacturer's specified RTK-GPS horizontal accuracy of 10 mm + 1 ppm

R 7. Sticking compensator in an automatic level

S 8. Incorrect temperature entered in a total station.

Descriptions

Describe these terms

a. Confidence interval

The certainty that a measurement will fall within a specific range.

b. Residual

The difference between an individual measurement and the most probable value of the measurement set.

c. Degree of freedom

The number of measurements beyond that needed to determine the unknown values. Also referred to as redundancy.

d. Error ellipse

The uncertainty at a specific confident interval of a horizontal position is an ellipse. It is a function of the standard errors in the east-west and north-south directions. The semi-major axis is oriented in the weakest direction with the semi-minor axis in the strongest.

e. Discrepancy

It is the difference between any two measurements of a measurement set.

f. Standard deviation

This represents ~68% of the area under the normal distribution curve. It is a range centered on the most probable value. It is an indicator of precision: the smaller the std dev the tighter (more precise) the set of measurements.

g. Crandall traverse adjustment method

This is a quasi-least square traverse adjustment techniques. It only adjusts distances by least squares; the angles are not adjusted.

Questions

Question (1)

What are the three sources of errors?

Sources are where they come from:

Natural - the environment within which measurements are made.

Instrumental - equipment used

Personal – knowledge and skill of the people performing the measurements

Question (2)

Two new technicians ran their first traverse around the exterior of a lot using a total station. Their data reduction is shown below.

Line	*Azimuth*	*Length (ft)*	*Latitude (ft)*	*Depature (ft)*	
A-B	30°00'00"	365.79	316.783	182.895	
B-C	325°33'52"	354.52	292.395	-200.474	
C-D	219°02'01"	645.84	-501.673	-406.735	
D-A	104°12'35"	437.64	-107.428	424.250	
	sums:	1,803.79	+0.077	-0.063	Precision= 1/18,100

High fives all around until one realized they hadn't entered the temperature and pressure in the instrument. They checked the instrument and found it was set to -15 ppm. Temperature and pressure at time of the fieldwork would have made the correction +20 ppm.

Part (a) What type of error is this?

a. Natural

b. Systematic

c. Random

d. Personal

Part (b) If they recomputed all their distances, how would it affect their traverse precision? Explain.

a. It would increase.

b. It would decrease.

c. It would not change

d. It would make it better.

This is a scaling error. All the distances would be multiplied by the same amount. The perimeter and closure distances would both increase/decrease by the same proportion.

Question (3)

As a joke, the new rod person was given a level rod that had the bottom half-foot cut off. If it was used for all the backsights and foresights on a level loop, would it affect loop closure? Why or why not?

Nope, it would not. Each rod reading has a 1-foot error. The error in the BS would be added, that in the FS subtracted, thereby canceling.

Problems

Problem (1)

If the total angular misclosure on for a six sided closed traverse cannot exceed ±00°00’25”, what is the allowable error for any single angle? Determine to nearest second.

Error of a series

$$E_{series} = E\sqrt{n}$$

$$\pm 00°00'25'' = E\sqrt{6}$$

$$\Rightarrow E = \frac{\pm 00°00'25''}{\sqrt{6}} = \pm 00°00'10.2062'' = \underline{\pm 00°00'10''}$$

Problem (2)

There are two different types of analog scales for weighing samples at a soils lab. A technician is asked to determine which scale is the more accurate of the two. She weights the same soil sample on each scale multiple times. Her results, in grams, are tabulated below. According to her measurements, which is the more accurate of the two scales? Show mathematically.

Scale A	v	v^2	Scale B	v	v^2
152.9	-0.38	0.1444	152.4	0.30	0.0900
152.2	+0.32	0.1024	152.8	-0.10	0.0100
152.8	-0.28	0.0784	152.7	0.00	0.0000
152.0	+0.52	0.2704	152.9	-0.20	0.0400
152.7	-0.18	0.0324	610.8		0.1400
762.6		0.6280			

$$MPV_A = \frac{762.6}{5} = 152.52 \qquad \sigma = \sqrt{\frac{0.6280}{5-1}} = \pm 0.39623 \qquad E_{MPVA} = \frac{\pm 0.39623}{\sqrt{5}} = \pm 0.177$$

$$MPV_B = \frac{610.8}{4} = 152.70 \qquad \sigma = \sqrt{\frac{0.1400}{4-1}} = \pm 0.21602 \qquad E_{MPVB} = \frac{\pm 0.21602}{\sqrt{4}} = \pm 0.108$$

<u>Scale B is more accurate because it has the smaller E_{MPV}.</u>

Problem (3)

In the process of indirectly determining the height of a flagpole, a survey crew measured the vertical angle at the instrument multiple times. Their measurements were: 56°18'51”, 56°18'59”, 56°18'49”, 56°18'54”, and 58°19’02”

What is the most probable value of the vertical angle along with its standard deviation and error of the mean? Compute all to the nearest second.

Angle	Angle-56°18	v	v^2
56°18'51”	51”	+4	16
56°18'59”	59”	-4	16
56°18'49”	49”	+6	36
56°18'54”	54”	+1	1
58°19’02”	62”	-7	49
	275		118

$$MPV = \frac{275"}{5} = 55" \Rightarrow 58°18'55"$$

$$\sigma = \sqrt{\frac{118}{5-1}} = \pm 5.43$$

$$E_{MPVA} = \frac{\pm 5.431}{\sqrt{5}} = \pm 2.429$$

58°18’55” ±00°00’05.4”, E_{PMV}=±00°00’02.4”

Problem (4)

A distance was measured multiple times by three crews each using a different method. Their results and precisions are shown in the table.

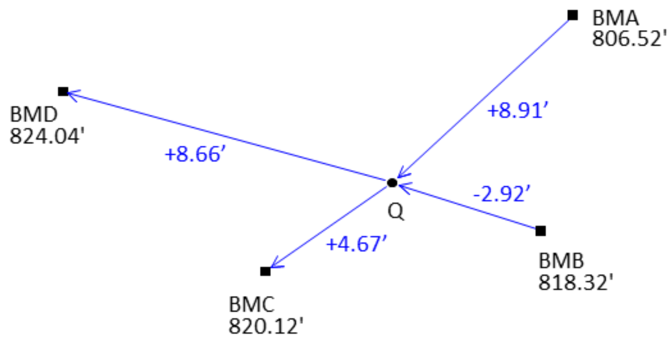
Method	*Distance (ft)*	*Precision*	w	w	w x m
Stadia	352.11	1/400	400	1	352.11
Steel tape	351.92	1/1000	1000	2.5	879.80
Total Station	351.35	1/10,000	10,000	25	8783.75
				28.5	10,015.66

Using all three crews’ information, what is the most probable distance? Compute to 0.001 ft

$$MPV = \frac{10{,}015.66}{28.5} = 351.42\overline{6} = \underline{351.427}$$

Problem (5)

The diagram below shows a differential leveling circuit connecting four benchmarks to an unknown elevation point Q. The arrows indicate the direction each line was run and the blue numbers are elevation differences in those directions. The elevation of each benchmark is shown by its name.



What is the most probable elevation of point Q? Determine to 0.001'.

Since there is only one unknown elevation and it is tied to each benchmark with a single measurement, its adjusted elevation is simply the average of the four elevations.

$$BMA: ElevQ = 806.52 + 8.91 = 815.43$$

$$BMB: ElevQ = 818.32 - 2.92 = 815.40$$

$$BMC: ElevQ = 820.12 - 4.67 = 815.45$$

$$BMD: ElevQ = 824.04 - 8.66 = 815.38$$

$$PV = \frac{3261.66}{4} = \underline{815.415}$$