## HP-33S Calculator Program Radiations 1

# Calculate a Radiation from Two Offsets

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| Line | Instruction | Display | User Instructions |
|---|---|---|---|
| Q0001 | LBL Q | | |
| Q0002 | SF 10 | | FLAGS SF .0 |
| Q0003 | ENTER RIGHT AZ | | EQN RCL E RCL N etc. ENTER to end |
| Q0004 | PSE | | |
| Q0005 | INPUT R | | |
| Q0006 | RCL R | | |
| Q0007 | →HR | | |
| Q0008 | STO A | | |
| Q0009 | ENTER LEFT AZ | | EQN RCL E RCL N etc. ENTER to end |
| Q0010 | PSE | | |
| Q0011 | INPUT L | | |
| Q0012 | RCL A | | |
| Q0013 | RCL L | | |
| Q0014 | →HR | | |
| Q0015 | – | | |
| Q0016 | STO E | | |
| Q0017 | ENTER RIGHT OS | | EQN RCL E RCL N etc. ENTER to end |
| Q0018 | PSE | | |
| Q0019 | INPUT R | | |
| Q0020 | ENTER LEFT OS | | EQN RCL E RCL N etc. ENTER to end |
| Q0021 | PSE | | |
| Q0022 | INPUT L | | |
| Q0023 | RCL R | | |
| Q0024 | RCL E | | |
| Q0025 | SIN | | |
| Q0026 | × | | |
| Q0027 | RCL E | | |
| Q0028 | COS | | |
| Q0029 | RCL× R | | |
| Q0030 | RCL+ L | | |
| Q0031 | ÷ | | |
| Q0032 | ATAN | | |
| Q0033 | STO C | | |
| Q0034 | RCL A | | |
| Q0035 | x < > y | | |
| Q0036 | – | | |
| Q0037 | →HMS | | |
| Q0038 | STO B | | |
| Q0039 | RADIATION AZ | | EQN RCL R RCL A etc. ENTER to end |

## Radiation from Two Offsets

| | | | |
|---|---|---|---|
| Q0040 | PSE | | |
| Q0041 | VIEW B | | |
| Q0042 | RCL R | | |
| Q0043 | RCL C | | |
| Q0044 | SIN | | |
| Q0045 | ÷ | | |
| Q0046 | STO D | | |
| Q0047 | RAD LENGTH | | EQN RCL R RCL A etc. ENTER to end |
| Q0048 | PSE | | |
| Q0049 | VIEW D | | |
| Q0050 | CF 10 | | FLAGS CF .0 |
| Q0051 | RTN | | |

## Notes

(1) This program allows a radiation (azimuth and distance) to an object to be computed from two offsets measured from two lines of known azimuth to the object.

(2) The two lines from which the offsets are measured do not have to be orthogonal. The closer they are to orthogonal, the better, but the program will work with any realistic set of measurements. It will also work across the 0° line, and with traverse lines in different quadrants.

(3) The purpose of the program is to facilitate conversion of older survey data, in which corners were often located by pairs of offsets, to a form in which a radiation is employed. This will simplify calculations based on traverses and radiations, i.e., vectors.

(4) Azimuths are entered and displayed in HP notation, i.e., DDD.MMSS, at all times.

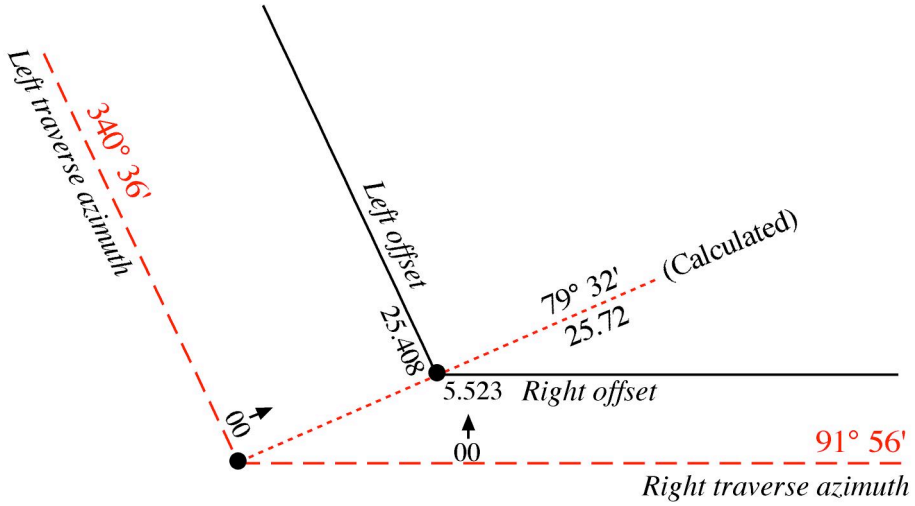
(5) Feet or meters (or any other linear units) can be used, provided their use is consistent.

(6) The original code for this program was developed by Philip R. Price at the State Rivers and Water Supply Commission (SR&WSC) Survey Branch, Victoria, Australia, in November, 1976, for the HP-25 calculator. This program is an update and adaptation for the HP-33S, but is based on Phil Price's original solution and HP-25 implementation.

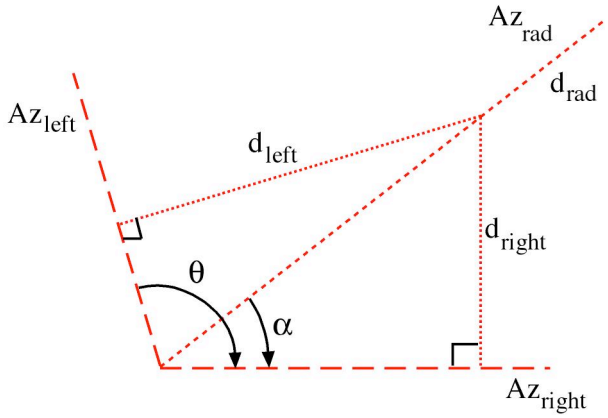
## Theory

If an object, commonly a corner, is located by offsets, these can be converted to the equivalent radiation using the program. In the above example, the corner was located by two offsets, being 5.523 on the right and 25.408 on the left. The offsets are measured at right angles to the respective traverse line, and are the distance between the object and the traverse line. The right traverse line has an azimuth of 91° 56', while the left traverse line has an azimuth of 340° 36'. See the figure on the next page.

# Radiation from Two Offsets




Generalizing the diagram and giving it symbols, the general situation becomes as follows.




The angle θ is the difference between the two known azimuths, $Az_{left}$ and $Az_{right}$.. The offset from the right traverse line to the object is $d_{right}$, while the offset from the left traverse line to the object is $d_{left}$. Because the offsets are measured at right angles to the traverse lines, their azimuths are also known.

The angle α is the angle between the right traverse line and the radiation, and is determined using the following formula:

$$\alpha = \arctan\left(\frac{d_{right} \sin\theta}{d_{left} + d_{right} \cos\theta}\right)$$

Subtracting α from $Az_{right}$ gives the azimuth of the radiation, $Az_{rad}$. The length of the radiation, $d_{rad}$, is derived using:

$$d_{rad} = \frac{d_{right}}{\sin\alpha}$$

# Radiation from Two Offsets

## Precision of Results

Note that the precision of the derived azimuth and distance is limited by the precision with which the offsets were measured, as well as the geometry of the offsets and radiation. The program provides the one solution given the data, but without redundant measurements the precision of the solution is unknown. It would be unwise to use azimuths for the radiation that are more precise that about one minute of arc. Experiment with changing the values of the offsets by small amounts that are consistent with their probable precision, and see what happens to the azimuth and distance values for the radiation.

## Sample Computations

1. Using the example given, where the right azimuth is 91° 56', the left azimuth is 340° 36', the right offset is 5.523 and the left offset is 25.408, the radiation has an azimuth of 79° 32' and a distance of 25.72.

2. Using a right azimuth of 160° 36' and a left azimuth of 91° 56', a right offset of 13.272 and a left offset of 15.693, the radiation has an azimuth of 129° 32' and a distance of 25.72.

3. Using a right azimuth of 268° 35', a left azimuth of 195° 12', a right offset of 11.782 and a left offset of 9.467, the radiation has an azimuth of 227° 15' and a distance of 17.84.

4. Using a right azimuth of 340° 36', a left azimuth of 271° 56', a right offset of 11.57 and a left offset of 8.78, the radiation has an azimuth of 300° 55' and a distance of 18.12.

## Running the Program

With everything to hand, press XEQ Q.

The calculator briefly displays ENTER RIGHT AZ, then prompts R?

> Key in the value of the azimuth of the right traverse line, in HP notation (DDD.MMSS). Press R/S.

The calculator briefly displays ENTER LEFT AZ, then prompts L?

> Key in the value of the azimuth of the left traverse line, in HP notation (DDD.MMSS). Press R/S.

The calculator briefly displays ENTER RIGHT OS, then prompts R?

> Key in the value of the right offset. Press R/S.

The calculator briefly displays ENTER LEFT OS, then prompts L?

> Key in the value of the left offset. Press R/S.

The calculator briefly displays RADIATION AZ, then shows B= and the azimuth in HP notation (DDD.MMSS). Press R/S.

The calculator briefly displays RAD LENGTH, then shows D= and the length of the radiation.

Press R/S to complete the program and clear the flag set at the start of the program.
To compute additional radiations from offset, press XEQ Q and start the program again.

# Radiation from Two Offsets

## Storage Registers Used

**A** Azimuth of right traverse line (in decimal degrees)

**B** Azimuth of the radiation (in HP notation, DDD.MMSS)

**C** $\alpha$, the angle between the right traverse line and the radiation (in decimal degrees)

**D** Length of the radiation

**E** $\theta$, the angle between the traverse lines (in decimal degrees)

**L** Left traverse azimuth (in HP notation) or left offset (temporary storage)

**R** Right traverse azimuth (in HP notation) or right offset (temporary storage)

## Labels Used

Label **Q** Length = 229 Checksum = F54A

Use the length (LN=) and Checksum (CK=) values to check if program was entered correctly. Use the sample computations to check proper operation after entry.