lasio Documentation

Release 0.28

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lasio is a Python 3 package to read and write Log ASCII Standard (LAS) files, used for borehole data such as geophysical, geological, or petrophysical logs. It's compatible with versions 1.2 and 2.0 of the LAS file specification, published by the Canadian Well Logging Society. In principle it is designed to read as many types of LAS files as possible, including ones containing common errors or non-compliant formatting.

Depending on your particular application you may also want to check out striplog for stratigraphic/lithological data, or (still in alpha dev) welly for dealing with data at the well level. lasio is primarily for reading & writing LAS files.

Note this is *not* a package for reading LiDAR data, which is also stored in "LAS" files.

The final version of lasio with Python 2.7 support is v0.26.

CHAPTER 1

Installation

lasio is written to be compatible with Python 3.2+. The best way to install is using pip.

```
$ pip install lasio
```

This will make sure that the dependency numpy is installed as well.

The final version of lasio with Python 2.7 support is v0.26.

There are some other packages which lasio will use to provide extra functionality if they are installed (pandas, cChardet and/or chardet, and openpyxl). I recommend installing these with:

lasio is now installed.

To upgrade to the latest PyPI version, use:

1.1 Development version

Installing via pip gets the latest release which has been published on PyPI. If you want, you can install the latest changes from GitHub:

1.2 Testing

Every time lasio is updated, automated tests are run using Travis CI on Python 3.5, 3.6, 3.7, and 3.8, on Linux. lasio should also work on Python 3.3, and 3.4 but these are not regularly tested.

To run tests yourself:

CHAPTER 2

Basic example

```
>>> import lasio
```

You can use *lasio.read()* to open any file or URL. For this tutorial I will use the `lasio.examples` module to load a LAS file which is bundled with lasio:

```
>>> import lasio.examples
>>> las = lasio.examples.open("1001178549.las")
```

The *lasio.read()* function returns a *lasio.LASFile* object. Each of the standard LAS sections can be accessed as an attribute:

```
>>> las.version
[HeaderItem(mnemonic="VERS", unit=, value="2.0", descr="CWLS Log ASCII Standard -V...
↪),
 HeaderItem(mnemonic="WRAP", unit=, value="YES", descr="Multiple lines per depth ...)]
```

Each LAS section is represented as a *lasio.SectionItems* object. The others, for LAS 2.0 files, are present as `las.well`, `las.curves`, and `las.params`; the ~O section is a string accessible at `las.other`.

You can also see the sections printed as an easier-to-read table:

```
>>> print(las.curves)
Mnemonic  Unit    Value         Description
--------  ----    -----         -----------
DEPT      FT      0   1  0  0   1 DEPTH
GSGR      API     31 310  0  0  2 GAMMA RAY
GSTK      API     31 797  0  0  3 ????????
GST       API     99 999 99  0  4 ????????
GSK       PERCNT  31 721  1  0  5 ????????
GSTH      PPM     31 790  0  0  6 THORIUM
GSUR      PPM     31 792  0  0  7 URANIUM
NCNPL     PERCNT  42 890  1  0  8 NEUTRON POROSITY (LIMESTONE)
DLDPL     PERCNT  43 890 10  0  9 DENSITY POROSITY (LIMESTONE)
DLDC      GM/CC   43 356  0  0  10 DENSITY CORRECTION
```

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```
DLPE      B/E     43 358  0  0  11 PHOTO-ELECTRIC EFFECT
DLDN      GM/CC   43 350  0  0  12 BULK DENSITY
DLCL      INCHES  43 280  0  0  13 CALIPER
DLTN      LBS     43 635  0  0  14 ????????
IDGR      API     7 310  0  0   15 GAMMA RAY
ACCL1     INCHES  60 280  1  0  16 DENSITY CALIPER
ACCL2     INCHES  60 280  2  0  17 NEUTRON CALIPER
ACTC      US/FT   60 520  0  0  18 SONIC INTERVAL TRANSIT TIME (COMPENSATED)
ACAPL     PERCNT  60 890 20  0  19 POROSITY
IDIM      OHMM    7 120 44  0   20 MEDIUM INDUCTION
IDID      OHMM    7 120 46  0   21 DEEP INDUCTION
IDIDC     MMHOS   7 110 46  0   22 INDUCTION (CONDUCTIVITY UNITS)
IDL3      OHMM    7 220  3  0   23 FOCUSSED RESISTIVITY
IDTN      LBS     7 635  0  0   24 ????????
IDSP      MVOLT   7  10  0  0   25 SPONTANEOUS POTENTIAL
MEL1      OHMM    15 250  2  0  26 MICRO INVERSE 1"
ME        OHMM    15 252  2  0  27 MICRO NORMAL 2"
```

The data is present as a `numpy.ndarray` at `las.data`:

```
>>> las.data.shape
(5, 27)
>>> las.data
array([[1.7835000e+03,           nan,           nan,           nan,
                  nan,           nan,           nan,           nan,
                  nan,           nan,           nan,           nan,
                  nan,           nan, 5.0646500e+01, 8.3871000e+00,
        8.4396000e+00, 5.5100000e+01, 5.6900000e-02, 5.6000000e+02,
        1.7500000e+02, 5.0000000e-02, 4.5330000e-01, 1.8930420e+03,
        9.2605000e+01,           nan,           nan],
       [1.7837500e+03,           nan,           nan,           nan,
                  nan,           nan,           nan,           nan,
                  nan,           nan,           nan,           nan,
                  nan,           nan, 4.9676700e+01, 8.3951000e+00,
        8.4460000e+00, 5.4355500e+01, 5.9000000e-02, 5.6000000e+02,
        1.7500000e+02, 5.0000000e-02, 4.5340000e-01, 1.8523320e+03,
        9.2778000e+01,           nan,           nan],
       [1.7840000e+03,           nan,           nan,           nan,
                  nan,           nan,           nan,           nan,
                  nan,           nan,           nan,           nan,
                  nan,           nan, 4.8631300e+01, 8.4052000e+00,
        8.4460000e+00, 5.4444400e+01, 5.8100000e-02, 5.6000000e+02,
        1.7500000e+02, 5.0000000e-02, 4.5370000e-01, 1.8319766e+03,
        9.2948200e+01,           nan,           nan],
       [1.7842500e+03,           nan,           nan,           nan,
                  nan,           nan,           nan,           nan,
                  nan,           nan,           nan,           nan,
                  nan,           nan, 4.7771700e+01, 8.4173000e+00,
        8.4438000e+00, 5.5311100e+01, 5.7700000e-02, 5.6000000e+02,
        1.7500000e+02, 5.0000000e-02, 4.5380000e-01, 1.8319766e+03,
        9.3110300e+01,           nan,           nan],
       [1.7845000e+03,           nan,           nan,           nan,
                  nan,           nan,           nan,           nan,
                  nan,           nan,           nan,           nan,
                  nan,           nan, 4.8114900e+01, 8.4253000e+00,
        8.4460000e+00, 5.6322200e+01, 5.8500000e-02, 5.6000000e+02,
        1.7500000e+02, 5.0000000e-02, 4.5390000e-01, 1.8116211e+03,
```

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```
        9.3267100e+01,           nan,           nan]])
```

Although it might be easier for you to iterate over the curves:

```
>>> for curve in las.curves:
...     print(curve.mnemonic + ": " + str(curve.data))
DEPT: [1783.5  1783.75 1784.   1784.25 1784.5 ]
GSGR: [nan nan nan nan nan]
GSTK: [nan nan nan nan nan]
GST: [nan nan nan nan nan]
GSK: [nan nan nan nan nan]
GSTH: [nan nan nan nan nan]
GSUR: [nan nan nan nan nan]
NCNPL: [nan nan nan nan nan]
DLDPL: [nan nan nan nan nan]
DLDC: [nan nan nan nan nan]
DLPE: [nan nan nan nan nan]
DLDN: [nan nan nan nan nan]
DLCL: [nan nan nan nan nan]
DLTN: [nan nan nan nan nan]
IDGR: [50.6465 49.6767 48.6313 47.7717 48.1149]
ACCL1: [8.3871 8.3951 8.4052 8.4173 8.4253]
ACCL2: [8.4396 8.446  8.446  8.4438 8.446 ]
ACTC: [55.1    54.3555 54.4444 55.3111 56.3222]
ACAPL: [0.0569 0.059  0.0581 0.0577 0.0585]
IDIM: [560. 560. 560. 560. 560.]
IDID: [175. 175. 175. 175. 175.]
IDIDC: [0.05 0.05 0.05 0.05 0.05]
IDL3: [0.4533 0.4534 0.4537 0.4538 0.4539]
IDTN: [1893.042  1852.332  1831.9766 1831.9766 1811.6211]
IDSP: [92.605  92.778  92.9482 93.1103 93.2671]
MEL1: [nan nan nan nan nan]
ME: [nan nan nan nan nan]
```

The first curve in the LAS file – usually the depth – is present as `las.index`, and curves are also accessible from the LASFile object as items. For example:

```
>>> las.index
array([1783.5 , 1783.75, 1784.  , 1784.25, 1784.5 ])
>>> las["IDTN"]
array([1893.042 , 1852.332 , 1831.9766, 1831.9766, 1811.6211])
```

CHAPTER 3

Integration with pandas.DataFrame

The *lasio.LASFile.df()* method converts the LAS data to a `pandas.DataFrame`. Any changes that you make to the DataFrame can be brought back into the LASFile object with *lasio.LASFile.set_data()*.

```
>>> import lasio.examples
>>> las = lasio.examples.open('6038187_v1.2.las')
>>> df = las.df()
```

There are some summary methods handy for data exploration:

```
>>> df.head(10)
        CALI   DFAR  DNEAR     GAMN  NEUT       PR     SP     COND
DEPT
0.05  49.765  4.587  3.382      NaN   NaN      NaN    NaN      NaN
0.10  49.765  4.587  3.382 -2324.28   NaN  115.508 -3.049 -116.998
0.15  49.765  4.587  3.382 -2324.28   NaN  115.508 -3.049 -116.998
0.20  49.765  4.587  3.382 -2324.28   NaN  115.508 -3.049 -116.998
0.25  49.765  4.587  3.382 -2324.28   NaN  115.508 -3.049 -116.998
0.30  49.765  4.587  3.382 -2324.28   NaN  115.508 -3.049 -116.998
0.35  49.765  4.587  3.382 -2324.28   NaN  115.508 -3.049 -116.998
0.40  49.765  4.587  3.382 -2324.28   NaN  115.508 -3.049 -116.998
0.45  49.765  4.587  3.382 -2324.28   NaN  115.508 -3.049 -116.998
0.50  49.765  4.587  3.382 -2324.28   NaN  115.508 -3.049 -116.998
>>> df.tail(40)
           CALI   DFAR  DNEAR     GAMN   NEUT       PR     SP     COND
DEPT
134.65  100.983  1.563  1.357 -2324.28  158.0  115.508 -3.049  578.643
134.70  100.833  1.570  1.357      NaN    NaN      NaN    NaN  571.233
134.75   93.760  1.582  1.378      NaN    NaN      NaN    NaN  565.552
134.80   88.086  1.561  1.361      NaN    NaN      NaN    NaN  570.490
134.85   86.443  1.516  1.338      NaN    NaN      NaN    NaN  574.937
134.90   79.617  5.989  1.356      NaN    NaN      NaN    NaN  579.137
134.95   65.236  4.587  1.397      NaN    NaN      NaN    NaN      NaN
135.00   55.833  4.587  1.351      NaN    NaN      NaN    NaN      NaN
135.05   49.061  4.587  1.329      NaN    NaN      NaN    NaN      NaN
```

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```
135.10   49.036    NaN    NaN      NaN    NaN      NaN    NaN      NaN
135.15   49.024    NaN    NaN      NaN    NaN      NaN    NaN      NaN
135.20   49.005    NaN    NaN      NaN    NaN      NaN    NaN      NaN
135.25   48.999    NaN    NaN      NaN    NaN      NaN    NaN      NaN
135.30   48.987    NaN    NaN      NaN    NaN      NaN    NaN      NaN
135.35   48.980    NaN    NaN      NaN    NaN      NaN    NaN      NaN
135.40   48.962    NaN    NaN      NaN    NaN      NaN    NaN      NaN
135.45   48.962    NaN    NaN      NaN    NaN      NaN    NaN      NaN
135.50   48.925    NaN    NaN      NaN    NaN      NaN    NaN      NaN
135.55   48.931    NaN    NaN      NaN    NaN      NaN    NaN      NaN
135.60   48.919    NaN    NaN      NaN    NaN      NaN    NaN      NaN
135.65   48.900    NaN    NaN      NaN    NaN      NaN    NaN      NaN
135.70   48.882    NaN    NaN      NaN    NaN      NaN    NaN      NaN
135.75   48.863    NaN    NaN      NaN    NaN      NaN    NaN      NaN
135.80   48.857    NaN    NaN      NaN    NaN      NaN    NaN      NaN
135.85   48.839    NaN    NaN      NaN    NaN      NaN    NaN      NaN
135.90   48.808    NaN    NaN      NaN    NaN      NaN    NaN      NaN
135.95   48.802    NaN    NaN      NaN    NaN      NaN    NaN      NaN
136.00   48.789    NaN    NaN      NaN    NaN      NaN    NaN      NaN
136.05   48.771    NaN    NaN      NaN    NaN      NaN    NaN      NaN
136.10   48.765    NaN    NaN      NaN    NaN      NaN    NaN      NaN
136.15   48.752    NaN    NaN      NaN    NaN      NaN    NaN      NaN
136.20   48.734    NaN    NaN      NaN    NaN      NaN    NaN      NaN
136.25   48.684    NaN    NaN      NaN    NaN      NaN    NaN      NaN
136.30   48.666    NaN    NaN      NaN    NaN      NaN    NaN      NaN
136.35   48.647    NaN    NaN      NaN    NaN      NaN    NaN      NaN
136.40   48.604    NaN    NaN      NaN    NaN      NaN    NaN      NaN
136.45   48.555    NaN    NaN      NaN    NaN      NaN    NaN      NaN
136.50   48.555    NaN    NaN      NaN    NaN      NaN    NaN      NaN
136.55   48.438    NaN    NaN      NaN    NaN      NaN    NaN      NaN
136.60  -56.275    NaN    NaN      NaN    NaN      NaN    NaN      NaN
>>> df.describe()
              CALI          DFAR         DNEAR          GAMN          NEUT  \
count  2732.000000  2701.000000  2701.000000  2691.000000  2492.000000
mean     97.432002     1.767922     1.729209  -102.330033   441.600013
std      13.939547     0.480333     0.372412   630.106420   370.138208
min     -56.275000     0.725000     0.657001 -2324.280000    81.001800
25%     101.077500     1.526000     1.535000    55.783000   158.002000
50%     101.426000     1.758000     1.785000    74.376900   256.501500
75%     101.582000     1.993000     1.948000    88.326900   680.500250
max     103.380000     5.989000     3.382000   169.672000  1665.990000

                 PR           SP          COND
count   2692.000000  2692.000000  2697.000000
mean   17940.522307    90.393464   478.670791
std    22089.297212    26.725547   753.869866
min      115.508000    -3.049000  -116.998000
25%     2652.470000    93.495500   200.981000
50%     2709.345000    99.994000   266.435000
75%    50499.900000   100.623000   505.530000
max    50499.900000   102.902000  4978.160000
```

There's obviously a problem with the GAMN log: -2324.28 is not a valid value. Let's fix that.

```
>>> import numpy as np
>>> df['GAMN'][df['GAMN'] == -2324.28] = np.nan
>>> df.describe()['GAMN']
```

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```
count    2491.000000
mean       76.068198
std        23.120160
min        13.946000
25%        60.434100
50%        76.700700
75%        90.647500
max       169.672000
Name: GAMN, dtype: float64
```

Let's create a new log with the moving average of the GAMN log, over 1 m. This is easy enough to do with the pandas `pandas.Series.rolling()` method and the LAS file's STEP value:

```
>>> df['GAMN_avg'] = df['GAMN'].rolling(int(1 / las.well.STEP.value), center=True).
↪mean()
```

Now we want to apply this DataFrame `df` back to the `las` LASFile object, and check that it's all there:

```
>>> las.set_data(df)
>>> las.curves
[CurveItem(mnemonic="DEPT", unit="M", value="", descr="DEPTH", original_mnemonic="DEPT
↪", data.shape=(2732,)),
 CurveItem(mnemonic="CALI", unit="MM", value="", descr="CALI", original_mnemonic="CALI
↪", data.shape=(2732,)),
 CurveItem(mnemonic="DFAR", unit="G/CM3", value="", descr="DFAR", original_mnemonic=
↪"DFAR", data.shape=(2732,)),
 CurveItem(mnemonic="DNEAR", unit="G/CM3", value="", descr="DNEAR", original_mnemonic=
↪"DNEAR", data.shape=(2732,)),
 CurveItem(mnemonic="GAMN", unit="GAPI", value="", descr="GAMN", original_mnemonic=
↪"GAMN", data.shape=(2732,)),
 CurveItem(mnemonic="NEUT", unit="CPS", value="", descr="NEUT", original_mnemonic=
↪"NEUT", data.shape=(2732,)),
 CurveItem(mnemonic="PR", unit="OHM/M", value="", descr="PR", original_mnemonic="PR",␣
↪data.shape=(2732,)),
 CurveItem(mnemonic="SP", unit="MV", value="", descr="SP", original_mnemonic="SP",␣
↪data.shape=(2732,)),
 CurveItem(mnemonic="COND", unit="MS/M", value="", descr="COND", original_mnemonic=
↪"COND", data.shape=(2732,)),
 CurveItem(mnemonic="GAMN_avg", unit="", value="", descr="", original_mnemonic="GAMN_
↪avg", data.shape=(2732,))]
>>> las.df().describe()
               CALI         DFAR        DNEAR         GAMN         NEUT  \
count  2732.000000  2701.000000  2701.000000  2491.000000  2492.000000
mean     97.432002     1.767922     1.729209    76.068198   441.600013
std      13.939547     0.480333     0.372412    23.120160   370.138208
min     -56.275000     0.725000     0.657001    13.946000    81.001800
25%     101.077500     1.526000     1.535000    60.434100   158.002000
50%     101.426000     1.758000     1.785000    76.700700   256.501500
75%     101.582000     1.993000     1.948000    90.647500   680.500250
max     103.380000     5.989000     3.382000   169.672000  1665.990000

                 PR           SP          COND     GAMN_avg
count   2692.000000  2692.000000  2697.000000  2472.000000
mean   17940.522307    90.393464   478.670791    76.326075
std    22089.297212    26.725547   753.869866    18.208038
min      115.508000    -3.049000  -116.998000    24.753655
```

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```
25%     2652.470000    93.495500   200.981000    64.848379
50%     2709.345000    99.994000   266.435000    77.747517
75%    50499.900000   100.623000   505.530000    88.323376
max    50499.900000   102.902000  4978.160000   120.049300
```

All good, the new curve is in there.

See the pandas documentation for more information!

CHAPTER 4

Header section metadata

4.1 Tutorial

One of the primary motivations in writing lasio was to be able to reliably parse LAS header sections. This is working fairly well for LAS 1.2 and 2.0 files, and lasio does not require LAS files to be strictly compliant with either standard.

```
>>> import lasio.examples
>>> las = lasio.examples.open('6038187_v1.2_short.las')
```

The header sections are stored in the dictionary `las.sections`:

```
>>> type(las.sections)
dict
>>> las.sections.keys()
dict_keys(['Version', 'Well', 'Curves', 'Parameter', 'Other'])
```

These are special names reserved for LAS 1.2 and 2.0 files, as defined by the standard. Non-standard header sections are also allowed but not fully parsed.

LAS file	Read in as	References in `LASFile`
`~v` or `~V`	*lasio.SectionItems*	`LASFile.version` and `LASFile.sections['Version']`
`~w` or `~W`	*lasio.SectionItems*	`LASFile.well` and `LASFile.sections['Well']`
`~c` or `~C`	*lasio.SectionItems*	`LASFile.curves` and `LASFile.sections['Curves']`
`~p` or `~P`	*lasio.SectionItems*	`LASFile.params` and `LASFile.sections['Parameter']`
`~o` or `~O`	`str`	`LASFile.other` and `LASFile.sections['Other']`
`~extra section`	`str`	`LASFile.sections['extra section']`
`~a` or `~A`	`numpy.ndarray`	`LASFile.data` or each column is in `LASFile.curves[...].data`

For example:

```
>>> las.sections['Version']
[HeaderItem(mnemonic="VERS", unit="", value="2.0", descr="CWLS LOG ASCII STANDA"),
 HeaderItem(mnemonic="WRAP", unit="", value="NO", descr="ONE LINE PER DEPTH STE")]

>>> las.version
[HeaderItem(mnemonic="VERS", unit="", value="2.0", descr="CWLS LOG ASCII STANDA"),
 HeaderItem(mnemonic="WRAP", unit="", value="NO", descr="ONE LINE PER DEPTH STE")]
```

Sections themselves are represented by *lasio.SectionItems* objects. This is a `list` which has been extended to allow you to access the items within by their mnemonic:

```
>>> las.version.VERS
HeaderItem(mnemonic="VERS", unit="", value="2.0", descr="CWLS LOG ASCII STANDA")
>>> las.version['VERS']
HeaderItem(mnemonic="VERS", unit="", value="2.0", descr="CWLS LOG ASCII STANDA")
>>> las.version[0]
HeaderItem(mnemonic="VERS", unit="", value="2.0", descr="CWLS LOG ASCII STANDA")
```

As you can see, either attribute-style or item-style access is fine.

Let's take a look at the next special section, `~W`:

```
>>> las.well
 [HeaderItem(mnemonic="STRT", unit="M", value="0.05", descr="FIRST INDEX VALUE"),
  HeaderItem(mnemonic="STOP", unit="M", value="136.6", descr="LAST INDEX VALUE"),
  HeaderItem(mnemonic="STEP", unit="M", value="0.05", descr="STEP"),
  HeaderItem(mnemonic="NULL", unit="", value="-99999", descr="NULL VALUE"),
  HeaderItem(mnemonic="COMP", unit="", value="", descr="COMP"),
  HeaderItem(mnemonic="WELL", unit="", value="Scorpio E1", descr="WELL"),
  HeaderItem(mnemonic="FLD", unit="", value="", descr=""),
  HeaderItem(mnemonic="LOC", unit="", value="Mt Eba", descr="LOC"),
  HeaderItem(mnemonic="SRVC", unit="", value="", descr=""),
  HeaderItem(mnemonic="CTRY", unit="", value="", descr=""),
  HeaderItem(mnemonic="STAT", unit="", value="SA", descr="STAT"),
  HeaderItem(mnemonic="CNTY", unit="", value="", descr=""),
  HeaderItem(mnemonic="DATE", unit="", value="15/03/2015", descr="DATE"),
  HeaderItem(mnemonic="UWI", unit="", value="6038-187", descr="WUNT")]
```

The CTRY item is blank. We will set it:

```
>>> las.well.CTRY = 'Australia'
>>> las.well.CTRY
HeaderItem(mnemonic="CTRY", unit="", value="Australia", descr="")
```

Notice that *lasio.SectionItems* plays a little trick here. It actually sets the `header_item.value` attribute, instead of replacing the entire *lasio.HeaderItem* object.

You can set any of the attributes directly. Let's take an example from the `~C` section:

```
>>> las.curves
[CurveItem(mnemonic="DEPT", unit="M", value="", descr="DEPTH", original_mnemonic="DEPT
↪", data.shape=(121,)),
 CurveItem(mnemonic="CALI", unit="MM", value="", descr="CALI", original_mnemonic="CALI
↪", data.shape=(121,)),
 CurveItem(mnemonic="DFAR", unit="G/CM3", value="", descr="DFAR", original_mnemonic=
↪"DFAR", data.shape=(121,)),
 CurveItem(mnemonic="DNEAR", unit="G/CM3", value="", descr="DNEAR", original_mnemonic=
↪"DNEAR", data.shape=(121,)),
```

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```
 CurveItem(mnemonic="GAMN", unit="GAPI", value="", descr="GAMN", original_mnemonic=
↪"GAMN", data.shape=(121,)),
 CurveItem(mnemonic="NEUT", unit="CPS", value="", descr="NEUT", original_mnemonic=
↪"NEUT", data.shape=(121,)),
 CurveItem(mnemonic="PR", unit="OHM/M", value="", descr="PR", original_mnemonic="PR",␣
↪data.shape=(121,)),
 CurveItem(mnemonic="SP", unit="MV", value="", descr="SP", original_mnemonic="SP",␣
↪data.shape=(121,)),
 CurveItem(mnemonic="COND", unit="MS/M", value="", descr="COND", original_mnemonic=
↪"COND", data.shape=(121,))]
>>> las.curves.PR.unit = 'ohmm'
>>> las.curves.PR
CurveItem(mnemonic="PR", unit="ohmm", value="", descr="PR", original_mnemonic="PR",␣
↪data.shape=(121,))
```

Now let's look more closely at how to manipulate and add or remove items from a section.

```
In [195]: las.params
Out[195]:
[HeaderItem(mnemonic="BS", unit="", value="216 mm", descr="BS"),
 HeaderItem(mnemonic="JOBN", unit="", value="", descr="JOBN"),
 HeaderItem(mnemonic="WPMT", unit="", value="", descr="WPMT"),
 HeaderItem(mnemonic="AGL", unit="", value="", descr="AGL"),
 HeaderItem(mnemonic="PURP", unit="", value="Cased hole stratigraphy", descr="P"),
 HeaderItem(mnemonic="X", unit="", value="560160", descr="X"),
 HeaderItem(mnemonic="CSGL", unit="", value="0 m - 135 m", descr="CSGL"),
 HeaderItem(mnemonic="UNIT", unit="", value="", descr="UNIT"),
 HeaderItem(mnemonic="Y", unit="", value="6686430", descr="Y"),
 HeaderItem(mnemonic="TDL", unit="", value="135.2 m", descr="TDL"),
 HeaderItem(mnemonic="PROD", unit="", value="", descr="PROD"),
 HeaderItem(mnemonic="MUD", unit="", value="Water", descr="MUD"),
 HeaderItem(mnemonic="CSGS", unit="", value="100 mm", descr="CSGS"),
 HeaderItem(mnemonic="ENG", unit="", value="", descr="ENG"),
 HeaderItem(mnemonic="STEP", unit="", value="5 cm", descr="STEP"),
 HeaderItem(mnemonic="FLUIDLEVEL", unit="", value="54 m", descr="FluidLevel"),
 HeaderItem(mnemonic="CSGT", unit="", value="PVC", descr="CSGT"),
 HeaderItem(mnemonic="WIT", unit="", value="", descr="WIT"),
 HeaderItem(mnemonic="EREF", unit="", value="", descr="EREF"),
 HeaderItem(mnemonic="PROJ", unit="", value="", descr="PROJ"),
 HeaderItem(mnemonic="ZONE", unit="", value="53J", descr="ZONE"),
 HeaderItem(mnemonic="DREF", unit="", value="GL", descr="DREF"),
 HeaderItem(mnemonic="TDD", unit="", value="136 m", descr="TDD")]
```

We want to rename the DREF mnemonic as LMF. We can do so by changing the `header_item.mnemonic` attribute.

```
>>> las.params.DREF.mnemonic = 'LMF'
>>> las.params
[HeaderItem(mnemonic="BS", unit="", value="216 mm", descr="BS"),
 HeaderItem(mnemonic="JOBN", unit="", value="", descr="JOBN"),
 HeaderItem(mnemonic="WPMT", unit="", value="", descr="WPMT"),
 HeaderItem(mnemonic="AGL", unit="", value="", descr="AGL"),
 HeaderItem(mnemonic="PURP", unit="", value="Cased hole stratigraphy", descr="P"),
 HeaderItem(mnemonic="X", unit="", value="560160", descr="X"),
 HeaderItem(mnemonic="CSGL", unit="", value="0 m - 135 m", descr="CSGL"),
 HeaderItem(mnemonic="UNIT", unit="", value="", descr="UNIT"),
```

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```
 HeaderItem(mnemonic="Y", unit="", value="6686430", descr="Y"),
 HeaderItem(mnemonic="TDL", unit="", value="135.2 m", descr="TDL"),
 HeaderItem(mnemonic="PROD", unit="", value="", descr="PROD"),
 HeaderItem(mnemonic="MUD", unit="", value="Water", descr="MUD"),
 HeaderItem(mnemonic="CSGS", unit="", value="100 mm", descr="CSGS"),
 HeaderItem(mnemonic="ENG", unit="", value="", descr="ENG"),
 HeaderItem(mnemonic="STEP", unit="", value="5 cm", descr="STEP"),
 HeaderItem(mnemonic="FLUIDLEVEL", unit="", value="54 m", descr="FluidLevel"),
 HeaderItem(mnemonic="CSGT", unit="", value="PVC", descr="CSGT"),
 HeaderItem(mnemonic="WIT", unit="", value="", descr="WIT"),
 HeaderItem(mnemonic="EREF", unit="", value="", descr="EREF"),
 HeaderItem(mnemonic="PROJ", unit="", value="", descr="PROJ"),
 HeaderItem(mnemonic="ZONE", unit="", value="53J", descr="ZONE"),
 HeaderItem(mnemonic="LMF", unit="", value="GL", descr="DREF"),
 HeaderItem(mnemonic="TDD", unit="", value="136 m", descr="TDD")]
```

And now we need to add a new mnemonic.

```
>>> las.params.DRILL = lasio.HeaderItem(mnemonic='DRILL', value='John Smith', descr=
↪'Driller on site')
>>> las.params
[HeaderItem(mnemonic="BS", unit="", value="216 mm", descr="BS"),
 HeaderItem(mnemonic="JOBN", unit="", value="", descr="JOBN"),
 HeaderItem(mnemonic="WPMT", unit="", value="", descr="WPMT"),
 HeaderItem(mnemonic="AGL", unit="", value="", descr="AGL"),
 HeaderItem(mnemonic="PURP", unit="", value="Cased hole stratigraphy", descr="P"),
 HeaderItem(mnemonic="X", unit="", value="560160", descr="X"),
 HeaderItem(mnemonic="CSGL", unit="", value="0 m - 135 m", descr="CSGL"),
 HeaderItem(mnemonic="UNIT", unit="", value="", descr="UNIT"),
 HeaderItem(mnemonic="Y", unit="", value="6686430", descr="Y"),
 HeaderItem(mnemonic="TDL", unit="", value="135.2 m", descr="TDL"),
 HeaderItem(mnemonic="PROD", unit="", value="", descr="PROD"),
 HeaderItem(mnemonic="MUD", unit="", value="Water", descr="MUD"),
 HeaderItem(mnemonic="CSGS", unit="", value="100 mm", descr="CSGS"),
 HeaderItem(mnemonic="ENG", unit="", value="", descr="ENG"),
 HeaderItem(mnemonic="STEP", unit="", value="5 cm", descr="STEP"),
 HeaderItem(mnemonic="FLUIDLEVEL", unit="", value="54 m", descr="FluidLevel"),
 HeaderItem(mnemonic="CSGT", unit="", value="PVC", descr="CSGT"),
 HeaderItem(mnemonic="WIT", unit="", value="", descr="WIT"),
 HeaderItem(mnemonic="EREF", unit="", value="", descr="EREF"),
 HeaderItem(mnemonic="PROJ", unit="", value="", descr="PROJ"),
 HeaderItem(mnemonic="ZONE", unit="", value="53J", descr="ZONE"),
 HeaderItem(mnemonic="LMF", unit="", value="GL", descr="DREF"),
 HeaderItem(mnemonic="TDD", unit="", value="136 m", descr="TDD"),
 HeaderItem(mnemonic="DRILL", unit="", value="John Smith", descr="Driller on si")]
```

Bingo.

What if we want to delete or remove an item? You can delete items the same way you would remove an item from a dictionary. Let's remove the item we just added (DRILL):

```
>>> del las.well["DRILL"]
```

There are methods intended for removing curves. Say you want to remove the PR curve:

```
>>> las.delete_curve("PR")
[CurveItem(mnemonic="DEPT", unit="M", value="", descr="DEPTH", original_mnemonic="DEPT
↪", data.shape=(121,)),
```

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```
 CurveItem(mnemonic="CALI", unit="MM", value="", descr="CALI", original_mnemonic="CALI
↪", data.shape=(121,)),
 CurveItem(mnemonic="DFAR", unit="G/CM3", value="", descr="DFAR", original_mnemonic=
↪"DFAR", data.shape=(121,)),
 CurveItem(mnemonic="DNEAR", unit="G/CM3", value="", descr="DNEAR", original_mnemonic=
↪"DNEAR", data.shape=(121,)),
 CurveItem(mnemonic="GAMN", unit="GAPI", value="", descr="GAMN", original_mnemonic=
↪"GAMN", data.shape=(121,)),
 CurveItem(mnemonic="NEUT", unit="CPS", value="", descr="NEUT", original_mnemonic=
↪"NEUT", data.shape=(121,)),
 CurveItem(mnemonic="SP", unit="MV", value="", descr="SP", original_mnemonic="SP",␣
↪data.shape=(121,)),
 CurveItem(mnemonic="COND", unit="MS/M", value="", descr="COND", original_mnemonic=
↪"COND", data.shape=(121,))]
```

Warning: Common mistake!

A common job is to iterate through the curves and remove all but a few that you are interested in. When doing this, be careful to iterate over a **copy** of the curves section:

```
>>> keep_curves = ['DEPT', 'DFAR', 'DNEAR']
>>> for curve in las.curves[:]:
...     if curve.mnemonic not in keep_curves:
...         las.delete_curve(curve.mnemonic)
...
>>> las.curves
[CurveItem(mnemonic="DEPT", unit="M", value="", descr="DEPTH", original_mnemonic="DEPT
↪", data.shape=(121,)),
 CurveItem(mnemonic="DFAR", unit="G/CM3", value="", descr="DFAR", original_mnemonic=
↪"DFAR", data.shape=(121,)),
 CurveItem(mnemonic="DNEAR", unit="G/CM3", value="", descr="DNEAR", original_mnemonic=
↪"DNEAR", data.shape=(121,))]
```

4.2 Handling errors

lasio will do its best to read every line from the header section. If it can make sense of it, it will parse it into a mnemonic, unit, value, and description. However often there are problems in LAS files. For example, a header section might contain something like:

```
COUNTY: RUSSELL
```

This line is missing a period. It should be `COUNTY. : RUSSELL`. Or another example:

```
API       .                                          : API Number     (required if␣
↪CTRY = US)
"# Surface Coords: 1,000' FNL & 2,000' FWL"
LATI      .DEG                                       : Latitude  - see Surface Coords␣
↪comment above
LONG      .DEG                                       : Longitude - see Surface Coords␣
↪comment above
```

Obviously the line with ” causes an error.

All these (and any other kind of error in the header section) can be turned from LASHeaderError exceptions into `logger.warning()` calls instead by using `lasio.read(..., ignore_header_errors=True)`. Here is an example. First we try reading a file without this argument:

```
>>> las = lasio.examples.open('dodgy_param_sect.las', ignore_header_errors=False)
Unable to parse line as LAS header: DEPTH     DT       RHOB     NPHI     SFLU
↪SFLA      ILM      ILD
Traceback (most recent call last):
  File "C:\Users\kinve\code\lasio\lasio\reader.py", line 525, in parse_header_section
    values = read_line(line, section_name=parser.section_name2)
  File "C:\Users\kinve\code\lasio\lasio\reader.py", line 711, in read_line
    return read_header_line(*args, **kwargs)
  File "C:\Users\kinve\code\lasio\lasio\reader.py", line 780, in read_header_line
    mdict = m.groupdict()
AttributeError: 'NoneType' object has no attribute 'groupdict'

During handling of the above exception, another exception occurred:

Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
  File "C:\Users\kinve\code\lasio\lasio\examples.py", line 46, in open
    return open_local_example(filename, **kwargs)
  File "C:\Users\kinve\code\lasio\lasio\examples.py", line 106, in open_local_example
    return LASFile(os.path.join(examples_path, *filename.split("/")), **kwargs)
  File "C:\Users\kinve\code\lasio\lasio\las.py", line 84, in __init__
    self.read(file_ref, **read_kwargs)
  File "C:\Users\kinve\code\lasio\lasio\las.py", line 222, in read
    mnemonic_case=mnemonic_case,
  File "C:\Users\kinve\code\lasio\lasio\las.py", line 142, in add_section
    raw_section, **sect_kws
  File "C:\Users\kinve\code\lasio\lasio\reader.py", line 536, in parse_header_section
    raise exceptions.LASHeaderError(message)
lasio.exceptions.LASHeaderError: line 31 (section ~PARAMETER INFORMATION): "DEPTH
↪DT       RHOB     NPHI     SFLU     SFLA      ILM      ILD"
```

Now if we use `ignore_header_errors=True`:

```
>>> las = lasio.examples.open('dodgy_param_sect.las', ignore_header_errors=True)
Unable to parse line as LAS header: DEPTH     DT       RHOB     NPHI     SFLU
↪SFLA      ILM      ILD
line 31 (section ~PARAMETER INFORMATION): "DEPTH     DT       RHOB     NPHI     SFLU
↪    SFLA      ILM      ILD"
```

Only a warning is issued, and the rest of the LAS file loads OK:

```
>>> las.params
[]
>>> las.curves
[CurveItem(mnemonic="DEPT", unit="M", value="", descr="1  DEPTH", original_mnemonic=
↪"DEPT", data.shape=(3,)),
 CurveItem(mnemonic="DT", unit="US/M", value="", descr="2  SONIC TRANSIT TIME",
↪original_mnemonic="DT", data.shape=(3,)),
 CurveItem(mnemonic="RHOB", unit="K/M3", value="", descr="3  BULK DENSITY", original_
↪mnemonic="RHOB", data.shape=(3,)),
 CurveItem(mnemonic="NPHI", unit="V/V", value="", descr="4   NEUTRON POROSITY",
↪original_mnemonic="NPHI", data.shape=(3,)),
 CurveItem(mnemonic="SFLU", unit="OHMM", value="", descr="5  RXO RESISTIVITY",
↪original_mnemonic="SFLU", data.shape=(3,)),
```

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```
 CurveItem(mnemonic="SFLA", unit="OHMM", value="", descr="6  SHALLOW RESISTIVITY",␣
↪original_mnemonic="SFLA", data.shape=(3,)),
 CurveItem(mnemonic="ILM", unit="OHMM", value="", descr="7  MEDIUM RESISTIVITY",␣
↪original_mnemonic="ILM", data.shape=(3,)),
 CurveItem(mnemonic="ILD", unit="OHMM", value="", descr="8  DEEP RESISTIVITY",␣
↪original_mnemonic="ILD", data.shape=(3,))
]
```

4.3 Handling duplicate mnemonics

Take this LAS file as an example, containing this ~C section:

```
~CURVE INFORMATION
DEPT.M                         :  1  DEPTH
DT  .US/M                             :  2  SONIC TRANSIT TIME
RHOB.K/M3                      :  3  BULK DENSITY
NPHI.V/V                       :  4   NEUTRON POROSITY
RXO.OHMM                       :  5  RXO RESISTIVITY
RES.OHMM                       :  6  SHALLOW RESISTIVITY
RES.OHMM                       :  7  MEDIUM RESISTIVITY
RES.OHMM                       :  8  DEEP RESISTIVITY
```

Notice there are three curves with the mnemonic RES. When we load the file in, lasio distinguishes between these duplicates:

```
>>> las = lasio.read('tests/examples/mnemonic_duplicate2.las')
>>> las.curves
[CurveItem(mnemonic="DEPT", unit="M", value="", descr="1  DEPTH", original_mnemonic=
↪"DEPT", data.shape=(3,)),
 CurveItem(mnemonic="DT", unit="US/M", value="", descr="2  SONIC TRANSIT TIME",␣
↪original_mnemonic="DT", data.shape=(3,)),
 CurveItem(mnemonic="RHOB", unit="K/M3", value="", descr="3  BULK DENSITY", original_
↪mnemonic="RHOB", data.shape=(3,)),
 CurveItem(mnemonic="NPHI", unit="V/V", value="", descr="4   NEUTRON POROSITY",␣
↪original_mnemonic="NPHI", data.shape=(3,)),
 CurveItem(mnemonic="RXO", unit="OHMM", value="", descr="5  RXO RESISTIVITY",␣
↪original_mnemonic="RXO", data.shape=(3,)),
 CurveItem(mnemonic="RES:1", unit="OHMM", value="", descr="6  SHALLOW RESISTIVITY",␣
↪original_mnemonic="RES", data.shape=(3,)),
 CurveItem(mnemonic="RES:2", unit="OHMM", value="", descr="7  MEDIUM RESISTIVITY",␣
↪original_mnemonic="RES", data.shape=(3,)),
 CurveItem(mnemonic="RES:3", unit="OHMM", value="", descr="8  DEEP RESISTIVITY",␣
↪original_mnemonic="RES", data.shape=(3,))
]
>>> las.curves['RES:2']
CurveItem(mnemonic="RES:2", unit="OHMM", value="", descr="7  MEDIUM RESISTIVITY",␣
↪original_mnemonic="RES", data.shape=(3,))
```

It remembers the original mnemonic, so when you write the file back out, they come back:

```
>>> from sys import stdout
>>> las.write(stdout)
~Version ------------------------------------------------
VERS. 1.2 : CWLS LOG ASCII STANDARD - VERSION 1.2
```

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```
WRAP.  NO : ONE LINE PER DEPTH STEP
~Well ------------------------------------------------------
STRT.M         1670.0 :
STOP.M        1669.75 :
STEP.M         -0.125 :
NULL.          -999.25 :
COMP.          COMPANY : # ANY OIL COMPANY LTD.
WELL.             WELL : ANY ET AL OIL WELL #12
FLD .            FIELD : EDAM
LOC .         LOCATION : A9-16-49-20W3M
PROV.         PROVINCE : SASKATCHEWAN
SRVC. SERVICE COMPANY : ANY LOGGING COMPANY LTD.
DATE.         LOG DATE : 25-DEC-1988
UWI .  UNIQUE WELL ID : 100091604920W300
~Curves ----------------------------------------------------
DEPT.M     : 1  DEPTH
DT  .US/M  : 2  SONIC TRANSIT TIME
RHOB.K/M3  : 3  BULK DENSITY
NPHI.V/V   : 4   NEUTRON POROSITY
RXO .OHMM  : 5  RXO RESISTIVITY
RES .OHMM  : 6  SHALLOW RESISTIVITY
RES .OHMM  : 7  MEDIUM RESISTIVITY
RES .OHMM  : 8  DEEP RESISTIVITY
~Params ----------------------------------------------------
BHT .DEGC   35.5 : BOTTOM HOLE TEMPERATURE
BS  .MM    200.0 : BIT SIZE
FD  .K/M3 1000.0 : FLUID DENSITY
MATR.        0.0 : NEUTRON MATRIX(0=LIME,1=SAND,2=DOLO)
MDEN.     2710.0 : LOGGING MATRIX DENSITY
RMF .OHMM  0.216 : MUD FILTRATE RESISTIVITY
DFD .K/M3 1525.0 : DRILL FLUID DENSITY
~Other -----------------------------------------------------
Note: The logging tools became stuck at 625 meters causing the data
between 625 meters and 615 meters to be invalid.
~ASCII -----------------------------------------------------
    1670     123.45       2550       0.45     123.45     123.45      110.2      105.6
    1669.9     123.45       2550       0.45     123.45     123.45      110.2      105.
↪6
    1669.8     123.45       2550       0.45     123.45     123.45      110.2      105.
↪6
```

4.3.1 Normalising mnemonic case

If there is a mix of upper and lower case characters in the mnemonics, by default lasio will convert all mnemonics to uppercase to avoid problems with producing the :1, :2, :3, and so on. There is a keyword argument which will preserve the original formatting if that is what you prefer.

```
>>> las = lasio.read('tests/examples/mnemonic_case.las')
>>> las.curves
[CurveItem(mnemonic="DEPT", unit="M", value="", descr="1  DEPTH", original_mnemonic=
↪"DEPT", data.shape=(3,)),
 CurveItem(mnemonic="SFLU:1", unit="K/M3", value="", descr="3  BULK DENSITY",␣
↪original_mnemonic="SFLU", data.shape=(3,)),
 CurveItem(mnemonic="NPHI", unit="V/V", value="", descr="4   NEUTRON POROSITY",␣
↪original_mnemonic="NPHI", data.shape=(3,)),
```

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```
 CurveItem(mnemonic="SFLU:2", unit="OHMM", value="", descr="5  RXO RESISTIVITY",␣
↪original_mnemonic="SFLU", data.shape=(3,)),
 CurveItem(mnemonic="SFLU:3", unit="OHMM", value="", descr="6  SHALLOW RESISTIVITY",␣
↪original_mnemonic="SFLU", data.shape=(3,)),
 CurveItem(mnemonic="SFLU:4", unit="OHMM", value="", descr="7  MEDIUM RESISTIVITY",␣
↪original_mnemonic="SFLU", data.shape=(3,)),
 CurveItem(mnemonic="SFLU:5", unit="OHMM", value="", descr="8  DEEP RESISTIVITY",␣
↪original_mnemonic="SFLU", data.shape=(3,))
]
>>> las = lasio.read('tests/examples/mnemonic_case.las', mnemonic_case='preserve')
>>> las.curves
[CurveItem(mnemonic="Dept", unit="M", value="", descr="1  DEPTH", original_mnemonic=
↪"Dept", data.shape=(3,)),
 CurveItem(mnemonic="Sflu", unit="K/M3", value="", descr="3  BULK DENSITY", original_
↪mnemonic="Sflu", data.shape=(3,)),
 CurveItem(mnemonic="NPHI", unit="V/V", value="", descr="4   NEUTRON POROSITY",␣
↪original_mnemonic="NPHI", data.shape=(3,)),
 CurveItem(mnemonic="SFLU:1", unit="OHMM", value="", descr="5  RXO RESISTIVITY",␣
↪original_mnemonic="SFLU", data.shape=(3,)),
 CurveItem(mnemonic="SFLU:2", unit="OHMM", value="", descr="6  SHALLOW RESISTIVITY",␣
↪original_mnemonic="SFLU", data.shape=(3,)),
 CurveItem(mnemonic="sflu", unit="OHMM", value="", descr="7  MEDIUM RESISTIVITY",␣
↪original_mnemonic="sflu", data.shape=(3,)),
 CurveItem(mnemonic="SfLu", unit="OHMM", value="", descr="8  DEEP RESISTIVITY",␣
↪original_mnemonic="SfLu", data.shape=(3,))
]
```

CHAPTER 5

Data section

5.1 Ignoring commented-out lines

Sometimes data sections have comment line inside them. By default lasio will ignore any lines starting with the "#" character within the data section. You can control this using the `remove_data_line_filter='#'` argument to *`lasio.LASFile.read()`*.

5.2 Handling errors

lasio has a flexible way of handling "errors" in the ~ASCII data section to accommodate how strict or flexible you want to be.

5.2.1 Example errors

Here are some examples of errors.

- Files could contain a variety of indicators for an invalid data point other than that defined by the NULL line in the LAS header (usually -999.25).
- Fixed-width columns could run into each other:

```
7686.500    64.932     0.123     0.395    12.403   156.271    10.649    -0.005   193.
↪223   327.902    -0.023     4.491     2.074    29.652
7686.000    67.354     0.140     0.415     9.207  4648.011    10.609    -0.004  3778.
↪709  1893.751    -0.048     4.513     2.041   291.910
7685.500    69.004     0.151     0.412     7.020101130.188    10.560    -0.004 60000.
↪000  2901.317    -0.047     4.492     2.046   310.119
7685.000    68.809     0.150     0.411     7.330109508.961    10.424    -0.005 60000.
↪000  2846.619    -0.042     4.538     2.049   376.968
```

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```
7684.500    68.633     0.149     0.402     7.345116238.453    10.515    -0.005 60000.
↪000  2290.275    -0.051     4.543     2.063   404.972
7684.000    68.008     0.144     0.386     7.682  4182.679    10.515    -0.004  3085.
↪681  1545.842    -0.046     4.484     2.089   438.195
```

- Odd text such as `(null)`:

```
8090.00         -999.25         -999.25         -999.25              0
↪0                0               0               0              0               0
↪            0
8091.000          0.70          337.70          (null)               0
↪0                0               0               0              0               0
↪            0
8092.000        -999.25         -999.25         -999.25              0
↪0                0               0               0              0               0
↪          0
```

5.2.2 Handling run-on errors

lasio detects and handles these problems by default using `lasio.read(f, read_policy='default')`. For example a file with this data section:

```
~A
    7686.000    67.354     0.140     0.415     9.207  4648.011    10.609
    7685.500    69.004     0.151     0.412     7.020101130.188    10.560
    7685.000    68.809     0.150     0.411     7.330-19508.961    10.424
    7684.500    68.633     0.149     0.402     7.345116238.453    10.515
    7684.000    68.008     0.144     0.386     7.682  4182.679    10.515
```

is loaded by default as the following:

```
>>> import lasio.examples
>>> las = lasio.examples.open('null_policy_runon.las')
>>> las.data
array([[7686.0, 67.354, 0.14, 0.415, 9.207, 4648.011, 10.609],
       [7685.5, 69.004, 0.151, 0.412, nan, nan, 10.56],
       [7685.0, 68.809, 0.15, 0.411, 7.33, -19508.961, 10.424],
       [7684.5, 68.633, 0.149, 0.402, nan, nan, 10.515],
       [7684.0, 68.008, 0.144, 0.386, 7.682, 4182.679, 10.515]])
```

5.2.3 Handling invalid data indicators automatically

These are detected by lasio to a degree which you can control with the null_policy keyword argument.

You can specify a policy of 'none', 'strict', 'common', 'aggressive', or 'all'. These policies all include a subset of pre-defined substitutions. Or you can give your own list of substitutions. Here is the list of predefined policies and substitutions from `lasio.defaults`.

Policies that you can pick with e.g. `null_policy='common'`:

```
NULL_POLICIES = {
    'none': [],
    'strict': ['NULL', ],
    'common': ['NULL', '(null)', '-',
```

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```
                '9999.25', '999.25', 'NA', 'INF', 'IO', 'IND'],
    'aggressive': ['NULL', '(null)', '--',
                   '9999.25', '999.25', 'NA', 'INF', 'IO', 'IND',
                   '999', '999.99', '9999', '9999.99' '2147483647', '32767',
                   '-0.0', ],
    'all': ['NULL', '(null)', '-',
            '9999.25', '999.25', 'NA', 'INF', 'IO', 'IND',
            '999', '999.99', '9999', '9999.99' '2147483647', '32767', '-0.0',
            'numbers-only', ],
    'numbers-only': ['numbers-only', ]
    }
```

Or substitutions you could specify with e.g. `null_policy=['NULL', '999.25', 'INF']`:

```
NULL_SUBS = {
    'NULL': [None, ],                          # special case to be handled
    '999.25': [-999.25, 999.25],
    '9999.25': [-9999.25, 9999.25],
    '999.99': [-999.99, 999.99],
    '9999.99': [-9999.99, 9999.99],
    '999': [-999, 999],
    '9999': [-9999, 9999],
    '2147483647': [-2147483647, 2147483647],
    '32767': [-32767, 32767],
    'NA': [(re.compile(r'(#N/A)[ ]'), ' NaN '),
           (re.compile(r'[ ](#N/A)'), ' NaN '), ],
    'INF': [(re.compile(r'(-?1\.#INF)[ ]'), ' NaN '),
            (re.compile(r'[ ](-?1\.#INF)'), ' NaN '), ],
    'IO': [(re.compile(r'(-?1\.#IO)[ ]'), ' NaN '),
           (re.compile(r'[ ](-?1\.#IO)'), ' NaN '), ],
    'IND': [(re.compile(r'(-?1\.#IND)[ ]'), ' NaN '),
            (re.compile(r'[ ](-?1\.#IND)'), ' NaN '), ],
    '-0.0': [(re.compile(r'(-?0\.0+)[ ]'), ' NaN '),
             (re.compile(r'[ ](-?0\.0+)'), ' NaN '), ],
    'numbers-only': [(re.compile(r'([^ 0-9.\-+]+)[ ]'), ' NaN '),
                     (re.compile(r'[ ]([^ 0-9.\-+]+)'), ' NaN '), ],
    }
```

You can also specify substitutions directly. E.g. for a file with this data section:

```
~A  DEPTH     DT       RHOB     NPHI     SFLU     SFLA      ILM      ILD
1670.000    9998  2550.000    0.450  123.450  123.450  110.200  105.600
1669.875    9999  2550.000    0.450  123.450  123.450  110.200  105.600
1669.750   10000       ERR    0.450  123.450  -999.25  110.200  105.600
```

By default, it will read all data as a string due to the presence of "ERR":

```
>>> las = lasio.examples.open('null_policy_ERR.las')
>>> las.data
array([['1670.0', '9998.0', '2550.0', '0.45', '123.45', '123.45',
        '110.2', '105.6'],
       ['1669.875', '9999.0', '2550.0', '0.45', '123.45', '123.45',
        '110.2', '105.6'],
       ['1669.75', '10000.0', 'ERR', '0.45', '123.45', '-999.25',
        '110.2', '105.6']], dtype='<U32')
```

We can fix it by using an explicit NULL policy.

```
>>> las = lasio.examples.open('null_policy_ERR.las', null_policy=[('ERR', ' NaN ')])
>>> las.data
array([[ 1.670000e+03,  9.998000e+03,  2.550000e+03,  4.500000e-01,
         1.234500e+02,  1.234500e+02,  1.102000e+02,  1.056000e+02],
       [ 1.669875e+03,  9.999000e+03,  2.550000e+03,  4.500000e-01,
         1.234500e+02,  1.234500e+02,  1.102000e+02,  1.056000e+02],
       [ 1.669750e+03,  1.000000e+04,           nan,  4.500000e-01,
         1.234500e+02, -9.992500e+02,  1.102000e+02,  1.056000e+02]])
```

See `tests/test_null_policy.py` (link) for some examples.

CHAPTER 6

Writing LAS files

Any LASFile object can be written to a new LAS file using the *lasio.LASFile.write()* method.

6.1 Converting between v1.2 and v2.0

Take this sample LAS 2.0 file:

```
~VERSION INFORMATION
 VERS.                          2.0 :   CWLS LOG ASCII STANDARD -VERSION 2.0
 WRAP.                          NO  :   ONE LINE PER DEPTH STEP
~WELL INFORMATION
#MNEM.UNIT              DATA                        DESCRIPTION
#----- -----            ----------                 -------------------------
STRT    .M              1670.0000                  :START DEPTH
STOP    .M              1660.0000                  :STOP DEPTH
STEP    .M              -0.1250                    :STEP
NULL    .               -999.25                    :NULL VALUE
COMP    .       ANY OIL COMPANY INC.               :COMPANY
WELL    .       AAAAA_2             :WELL
FLD     .       WILDCAT                            :FIELD
LOC     .       12-34-12-34W5M                     :LOCATION
PROV    .       ALBERTA                            :PROVINCE
SRVC    .       ANY LOGGING COMPANY INC.           :SERVICE COMPANY
DATE    .       13-DEC-86                          :LOG DATE
UWI     .       100123401234W500                   :UNIQUE WELL ID
~CURVE INFORMATION
#MNEM.UNIT              API CODES                     CURVE DESCRIPTION
#------------------     ------------                 -------------------------
 DEPT   .M                                         :  1  DEPTH
 DT     .US/M           60 520 32 00               :  2  SONIC TRANSIT TIME
 RHOB   .K/M3           45 350 01 00               :  3  BULK DENSITY
 NPHI   .V/V            42 890 00 00               :  4  NEUTRON POROSITY
 SFLU   .OHMM           07 220 04 00               :  5  SHALLOW RESISTIVITY
```

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```
 SFLA    .OHMM            07 222 01 00              :  6  SHALLOW RESISTIVITY
 ILM     .OHMM            07 120 44 00              :  7  MEDIUM RESISTIVITY
 ILD     .OHMM            07 120 46 00              :  8  DEEP RESISTIVITY
~PARAMETER INFORMATION
#MNEM.UNIT               VALUE              DESCRIPTION
#--------------      ----------------      ------------------------------------------
 MUD     .                GEL CHEM        :   MUD TYPE
 BHT     .DEGC            35.5000         :   BOTTOM HOLE TEMPERATURE
 BS      .MM              200.0000        :   BIT SIZE
 FD      .K/M3            1000.0000       :   FLUID DENSITY
 MATR    .                SAND            :   NEUTRON MATRIX
 MDEN    .                2710.0000       :   LOGGING MATRIX DENSITY
 RMF     .OHMM            0.2160          :   MUD FILTRATE RESISTIVITY
 DFD     .K/M3            1525.0000       :   DRILL FLUID DENSITY
~OTHER
     Note: The logging tools became stuck at 625 metres causing the data
     between 625 metres and 615 metres to be invalid.
~A  DEPTH     DT    RHOB        NPHI   SFLU    SFLA      ILM      ILD
1670.000   123.450 2550.000    0.450  123.450  123.450  110.200  105.600
1669.875   123.450 2550.000    0.450  123.450  123.450  110.200  105.600
1669.750   123.450 2550.000    0.450  123.450  123.450  110.200  105.600
```

And we can use lasio to convert it to LAS 1.2:

```
>>> las = lasio.examples.open("2.0/sample_2.0.las")
>>> las.write('example-as-v1.2.las', version=1.2)
```

```
~Version ------------------------------------------------
VERS. 1.2 : CWLS LOG ASCII STANDARD - VERSION 1.2
WRAP.  NO : ONE LINE PER DEPTH STEP
~Well ---------------------------------------------------
STRT.M         1670.0 : START DEPTH
STOP.M        1669.75 : STOP DEPTH
STEP.M         -0.125 : STEP
NULL.         -999.25 : NULL VALUE
COMP.         COMPANY : ANY OIL COMPANY INC.
WELL.            WELL : AAAAA_2
FLD .           FIELD : WILDCAT
LOC .        LOCATION : 12-34-12-34W5M
PROV.        PROVINCE : ALBERTA
SRVC. SERVICE COMPANY : ANY LOGGING COMPANY INC.
DATE.        LOG DATE : 13-DEC-86
UWI .  UNIQUE WELL ID : 100123401234W500
~Curves -------------------------------------------------
DEPT.M                 : 1  DEPTH
DT  .US/M 60 520 32 00 : 2  SONIC TRANSIT TIME
RHOB.K/M3 45 350 01 00 : 3  BULK DENSITY
NPHI.V/V  42 890 00 00 : 4  NEUTRON POROSITY
SFLU.OHMM 07 220 04 00 : 5  SHALLOW RESISTIVITY
SFLA.OHMM 07 222 01 00 : 6  SHALLOW RESISTIVITY
ILM .OHMM 07 120 44 00 : 7  MEDIUM RESISTIVITY
ILD .OHMM 07 120 46 00 : 8  DEEP RESISTIVITY
~Params -------------------------------------------------
MUD .   GEL CHEM : MUD TYPE
BHT .DEGC   35.5 : BOTTOM HOLE TEMPERATURE
```

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```
BS  .MM    200.0 : BIT SIZE
FD  .K/M3 1000.0 : FLUID DENSITY
MATR.       SAND : NEUTRON MATRIX
MDEN.     2710.0 : LOGGING MATRIX DENSITY
RMF .OHMM  0.216 : MUD FILTRATE RESISTIVITY
DFD .K/M3 1525.0 : DRILL FLUID DENSITY
~Other ------------------------------------------------
Note: The logging tools became stuck at 625 metres causing the data
between 625 metres and 615 metres to be invalid.
~ASCII -------------------------------------------------
       1670     123.45       2550       0.45     123.45     123.45      110.2
↪105.6
     1669.9     123.45       2550       0.45     123.45     123.45      110.2
↪105.6
     1669.8     123.45       2550       0.45     123.45     123.45      110.2
↪105.6
```

6.2 Converting between wrapped/unwrapped

Here is an example using this file to convert a wrapped data section to unwrapped.

```
~Version Information
 VERS.                 1.20:   CWLS log ASCII Standard -VERSION 1.20
 WRAP.                  YES:   Multiple lines per depth step
~Well Information
#MNEM.UNIT       Data Type    Information
#---------    -------------   ------------------------------
 STRT.M            910.000:
 STOP.M            901.000:
 STEP.M            -0.1250:
 NULL.           -999.2500:   Null value
 COMP.             COMPANY:   ANY OIL COMPANY INC.
 WELL.                WELL:   ANY ET AL XX-XX-XX-XX
 FLD .               FIELD:   WILDCAT
 LOC .            LOCATION:   XX-XX-XX-XXW3M
 PROV.            PROVINCE:   SASKATCHEWAN
 SRVC.     SERVICE COMPANY:   ANY LOGGING COMPANY INC.
 SON .     SERVICE ORDER :   142085
 DATE.           LOG DATE:   13-DEC-86
 UWI .      UNIQUE WELL ID:
~Curve Information
#MNEM.UNIT      API CODE      Curve Description
#---------    -------------   ------------------------------
 DEPT.M                      :    Depth
 DT  .US/M                   :  1 Sonic Travel Time
 RHOB.K/M                    :  2 Density-Bulk Density
 NPHI.V/V                    :  3 Porosity -Neutron
 RX0 .OHMM                   :  4 Resistivity -Rxo
 RESS.OHMM                   :  5 Resistivity -Shallow
 RESM.OHMM                   :  6 Resistivity -Medium
 RESD.OHMM                   :  7 Resistivity -Deep
 SP  .MV                     :  8 Spon. Potential
 GR  .GAPI                   :  9 Gamma Ray
 CALI.MM                     : 10 Caliper
```

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```
 DRHO.K/M3                      : 11 Delta-Rho
 EATT.DBM                       : 12 EPT Attenuation
 TPL .NS/M                      : 13 TP -EPT
 PEF .                          : 14 PhotoElectric Factor
 FFI .V/V                       : 15 Porosity -NML FFI
 DCAL.MM                        : 16 Caliper-Differential
 RHGF.K/M3                      : 17 Density-Formation
 RHGA.K/M3                      : 18 Density-Apparent
 SPBL.MV                        : 19 Baselined SP
 GRC .GAPI                      : 20 Gamma Ray BHC
 PHIA.V/V                       : 21 Porosity -Apparent
 PHID.V/V                       : 22 Porosity -Density
 PHIE.V/V                       : 23 Porosity -Effective
 PHIN.V/V                       : 24 Porosity -Neut BHC
 PHIC.V/V                       : 25 Porosity -Total HCC
 R0  .OHMM                      : 26 Ro
 RWA .OHMM                      : 27 Rfa
 SW   .                         : 28 Sw -Effective
 MSI .                          : 29 Sh Idx -Min
 BVW .                          : 30 BVW
 FGAS.                          : 31 Flag -Gas Index
 PIDX.                          : 32 Prod Idx
 FBH .                          : 33 Flag -Bad Hole
 FHCC.                          : 34 Flag -HC Correction
 LSWB.                          : 35 Flag -Limit SWB
~A Log data section
910.000000
  -999.2500  2692.7075     0.3140    19.4086    19.4086    13.1709    12.2681
    -1.5010    96.5306   204.7177    30.5822  -999.2500  -999.2500     3.2515
  -999.2500     4.7177  3025.0264  3025.0264    -1.5010    93.1378     0.1641
     0.0101     0.1641     0.3140     0.1641    11.1397     0.3304     0.9529
     0.0000     0.1564     0.0000    11.1397     0.0000     0.0000     0.0000
909.875000
  -999.2500  2712.6460     0.2886    23.3987    23.3987    13.6129    12.4744
    -1.4720    90.2803   203.1093    18.7566  -999.2500  -999.2500     3.7058
  -999.2500     3.1093  3004.6050  3004.6050    -1.4720    86.9078     0.1456
    -0.0015     0.1456     0.2886     0.1456    14.1428     0.2646     1.0000
     0.0000     0.1456     0.0000    14.1428     0.0000     0.0000     0.0000
909.750000
  -999.2500  2692.8137     0.2730    22.5909    22.5909    13.6821    12.6146
    -1.4804    89.8492   201.9287     3.1551  -999.2500  -999.2500     4.3124
  -999.2500     1.9287  2976.4451  2976.4451    -1.4804    86.3465     0.1435
     0.0101     0.1435     0.2730     0.1435    14.5674     0.2598     1.0000
     0.0000     0.1435     0.0000    14.5674     0.0000     0.0000     0.0000
909.625000
  -999.2500  2644.3650     0.2765    18.4831    18.4831    13.4159    12.6900
    -1.5010    93.3999   201.5826    -6.5861  -999.2500  -999.2500     4.3822
  -999.2500     1.5826  2955.3528  2955.3528    -1.5010    89.7142     0.1590
     0.0384     0.1590     0.2765     0.1590    11.8600     0.3210     0.9667
     0.0000     0.1538     0.0000    11.8600     0.0000     0.0000     0.0000
909.500000
  -999.2500  2586.2822     0.2996    13.9187    13.9187    12.9195    12.7016
    -1.4916    98.1214   201.7126    -4.5574  -999.2500  -999.2500     3.5967
  -999.2500     1.7126  2953.5940  2953.5940    -1.4916    94.2670     0.1880
     0.0723     0.1880     0.2996     0.1880     8.4863     0.4490     0.8174
     0.0000     0.1537     0.0000     8.4863     0.0000     0.0000     0.0000
```

We will change the wrap by adjusting the relevant header section in the LASFile header:

```
>>> las.version
[HeaderItem(mnemonic="VERS", unit="", value="1.2", descr="CWLS log ASCII Standa"),
 HeaderItem(mnemonic="WRAP", unit="", value="YES", descr="Multiple lines per de")]

>>> las.version.WRAP = 'NO'
>>> las.version.WRAP
HeaderItem(mnemonic="WRAP", unit="", value="NO", descr="Multiple lines per dep")
>>> las.write('example-unwrapped.las')
WARNING:lasio.writer:[v1.2] line #58 has 396 chars (>256)
WARNING:lasio.writer:[v1.2] line #59 has 396 chars (>256)
WARNING:lasio.writer:[v1.2] line #60 has 396 chars (>256)
WARNING:lasio.writer:[v1.2] line #61 has 396 chars (>256)
WARNING:lasio.writer:[v1.2] line #62 has 396 chars (>256)
```

We get warnings because the LAS 1.2 standard doesn't allow writing lines longer than 256 characters. lasio provides the warning but still produces the long lines:

```
~Version ------------------------------------------------
VERS. 1.2 : CWLS LOG ASCII STANDARD - VERSION 1.2
WRAP.  NO : Multiple lines per depth step
~Well ---------------------------------------------------
STRT.M          910.0 :
STOP.M          909.5 :
STEP.M         -0.125 :
NULL.         -999.25 : Null value
COMP.         COMPANY : ANY OIL COMPANY INC.
WELL.            WELL : ANY ET AL XX-XX-XX-XX
FLD .           FIELD : WILDCAT
LOC .        LOCATION : XX-XX-XX-XXW3M
PROV.        PROVINCE : SASKATCHEWAN
SRVC. SERVICE COMPANY : ANY LOGGING COMPANY INC.
SON .   SERVICE ORDER : 142085
DATE.        LOG DATE : 13-DEC-86
UWI .  UNIQUE WELL ID :
~Curves -------------------------------------------------
DEPT.M     : Depth
DT  .US/M  : 1 Sonic Travel Time
RHOB.K/M   : 2 Density-Bulk Density
NPHI.V/V   : 3 Porosity -Neutron
RX0 .OHMM  : 4 Resistivity -Rxo
RESS.OHMM  : 5 Resistivity -Shallow
RESM.OHMM  : 6 Resistivity -Medium
RESD.OHMM  : 7 Resistivity -Deep
SP  .MV    : 8 Spon. Potential
GR  .GAPI  : 9 Gamma Ray
CALI.MM    : 10 Caliper
DRHO.K/M3  : 11 Delta-Rho
EATT.DBM   : 12 EPT Attenuation
TPL .NS/M  : 13 TP -EPT
PEF .      : 14 PhotoElectric Factor
FFI .V/V   : 15 Porosity -NML FFI
DCAL.MM    : 16 Caliper-Differential
RHGF.K/M3  : 17 Density-Formation
RHGA.K/M3  : 18 Density-Apparent
SPBL.MV    : 19 Baselined SP
GRC .GAPI  : 20 Gamma Ray BHC
```

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```
PHIA.V/V   : 21 Porosity -Apparent
PHID.V/V   : 22 Porosity -Density
PHIE.V/V   : 23 Porosity -Effective
PHIN.V/V   : 24 Porosity -Neut BHC
PHIC.V/V   : 25 Porosity -Total HCC
R0  .OHMM  : 26 Ro
RWA .OHMM  : 27 Rfa
SW  .      : 28 Sw -Effective
MSI .      : 29 Sh Idx -Min
BVW .      : 30 BVW
FGAS.      : 31 Flag -Gas Index
PIDX.      : 32 Prod Idx
FBH .      : 33 Flag -Bad Hole
FHCC.      : 34 Flag -HC Correction
LSWB.      : 35 Flag -Limit SWB
~Params ----------------------------------------------------
~Other -----------------------------------------------------
~ASCII -----------------------------------------------------
        910    -999.25     2692.7      0.314     19.409     19.409     13.171     12.
↪268     -1.501     96.531     204.72     30.582    -999.25    -999.25     3.2515
↪-999.25     4.7177       3025       3025     -1.501     93.138     0.1641      0.
↪0101     0.1641      0.314     0.1641      11.14     0.3304     0.9529          0
↪  0.1564          0      11.14          0          0          0
     909.88    -999.25     2712.6     0.2886     23.399     23.399     13.613     12.
↪474     -1.472      90.28     203.11     18.757    -999.25    -999.25     3.7058
↪-999.25     3.1093     3004.6     3004.6     -1.472     86.908     0.1456    -0.
↪0015     0.1456     0.2886     0.1456     14.143     0.2646          1          0
↪  0.1456          0     14.143          0          0          0
     909.75    -999.25     2692.8      0.273     22.591     22.591     13.682     12.
↪615    -1.4804     89.849     201.93     3.1551    -999.25    -999.25     4.3124
↪-999.25     1.9287     2976.4     2976.4    -1.4804     86.347     0.1435      0.
↪0101     0.1435      0.273     0.1435     14.567     0.2598          1          0
↪  0.1435          0     14.567          0          0          0
     909.62    -999.25     2644.4     0.2765     18.483     18.483     13.416      12.
↪69     -1.501       93.4     201.58    -6.5861    -999.25    -999.25     4.3822     -
↪999.25     1.5826     2955.4     2955.4     -1.501     89.714      0.159     0.0384
↪     0.159     0.2765      0.159      11.86      0.321     0.9667          0     0.
↪1538          0      11.86          0          0          0
      909.5    -999.25     2586.3     0.2996     13.919     13.919     12.919     12.
↪702    -1.4916     98.121     201.71    -4.5574    -999.25    -999.25     3.5967
↪-999.25     1.7126     2953.6     2953.6    -1.4916     94.267      0.188      0.
↪0723      0.188     0.2996      0.188     8.4863      0.449     0.8174          0
↪  0.1537          0     8.4863          0          0          0
```

If we decide to write the file in LAS 2.0 format, the warnings will go away:

```
>>> las.write('example-version-2.0.las', version=2.0)
```

```
~Version ---------------------------------------------------
VERS. 2.0 : CWLS log ASCII Standard -VERSION 2.0
WRAP.  NO : Multiple lines per depth step
~Well ------------------------------------------------------
STRT.M                  910.0 :
STOP.M                  909.5 :
STEP.M                 -0.125 :
NULL.                -999.25 : Null value
```

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```
COMP.     ANY OIL COMPANY INC. : COMPANY
WELL.    ANY ET AL XX-XX-XX-XX : WELL
FLD .                  WILDCAT : FIELD
LOC .           XX-XX-XX-XXW3M : LOCATION
PROV.             SASKATCHEWAN : PROVINCE
SRVC. ANY LOGGING COMPANY INC. : SERVICE COMPANY
SON .                   142085 : SERVICE ORDER
DATE.                13-DEC-86 : LOG DATE
UWI .                          : UNIQUE WELL ID
~Curves ------------------------------------------------
DEPT.M     : Depth
DT  .US/M  : 1 Sonic Travel Time
RHOB.K/M   : 2 Density-Bulk Density
NPHI.V/V   : 3 Porosity -Neutron
RX0 .OHMM  : 4 Resistivity -Rxo
RESS.OHMM  : 5 Resistivity -Shallow
RESM.OHMM  : 6 Resistivity -Medium
RESD.OHMM  : 7 Resistivity -Deep
SP  .MV    : 8 Spon. Potential
GR  .GAPI  : 9 Gamma Ray
CALI.MM    : 10 Caliper
DRHO.K/M3  : 11 Delta-Rho
EATT.DBM   : 12 EPT Attenuation
TPL .NS/M  : 13 TP -EPT
PEF .      : 14 PhotoElectric Factor
FFI .V/V   : 15 Porosity -NML FFI
DCAL.MM    : 16 Caliper-Differential
RHGF.K/M3  : 17 Density-Formation
RHGA.K/M3  : 18 Density-Apparent
SPBL.MV    : 19 Baselined SP
GRC .GAPI  : 20 Gamma Ray BHC
PHIA.V/V   : 21 Porosity -Apparent
PHID.V/V   : 22 Porosity -Density
PHIE.V/V   : 23 Porosity -Effective
PHIN.V/V   : 24 Porosity -Neut BHC
PHIC.V/V   : 25 Porosity -Total HCC
R0  .OHMM  : 26 Ro
RWA .OHMM  : 27 Rfa
SW  .      : 28 Sw -Effective
MSI .      : 29 Sh Idx -Min
BVW .      : 30 BVW
FGAS.      : 31 Flag -Gas Index
PIDX.      : 32 Prod Idx
FBH .      : 33 Flag -Bad Hole
FHCC.      : 34 Flag -HC Correction
LSWB.      : 35 Flag -Limit SWB
~Params ------------------------------------------------
~Other -------------------------------------------------
~ASCII -------------------------------------------------
        910    -999.25     2692.7      0.314     19.409     19.409     13.171     12.
↪268     -1.501     96.531     204.72     30.582    -999.25    -999.25     3.2515
↪-999.25     4.7177       3025       3025     -1.501     93.138     0.1641     0.
↪0101     0.1641      0.314     0.1641      11.14     0.3304     0.9529          0
↪  0.1564          0      11.14          0          0          0
     909.88    -999.25     2712.6     0.2886     23.399     23.399     13.613     12.
↪474     -1.472      90.28     203.11     18.757    -999.25    -999.25     3.7058
↪-999.25     3.1093     3004.6     3004.6     -1.472     86.908     0.1456    -0.
↪0015     0.1456     0.2886     0.1456     14.143     0.2646          1          0
↪  0.1456          0     14.143          0          0          0
```

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```
60      909.75     -999.25      2692.8       0.273      22.591      22.591      13.682      12.
↪615     -1.4804      89.849      201.93      3.1551     -999.25     -999.25      4.3124
↪-999.25      1.9287      2976.4      2976.4     -1.4804      86.347      0.1435      0.
↪0101      0.1435       0.273      0.1435      14.567      0.2598           1           0
↪   0.1435           0      14.567           0           0           0
61      909.62     -999.25      2644.4      0.2765      18.483      18.483      13.416      12.
↪69      -1.501        93.4      201.58     -6.5861     -999.25     -999.25      4.3822     -
↪999.25      1.5826      2955.4      2955.4      -1.501      89.714       0.159      0.0384
↪      0.159      0.2765       0.159       11.86       0.321      0.9667           0      0.
↪1538           0       11.86           0           0           0
62       909.5     -999.25      2586.3      0.2996      13.919      13.919      12.919      12.
↪702     -1.4916      98.121      201.71     -4.5574     -999.25     -999.25      3.5967
↪-999.25      1.7126      2953.6      2953.6     -1.4916      94.267       0.188      0.
↪0723       0.188      0.2996       0.188      8.4863       0.449      0.8174           0
↪   0.1537           0      8.4863           0           0           0
```

CHAPTER 7

Exporting to other formats

7.1 Comma-separated values (CSV)

lasio.LASFile objects can be converted to CSV files with a few options for how mnemonics and units are included (or not). It uses the *lasio.LASFile.to_csv()* method.

```
>>> import lasio.examples
>>> from sys import stdout
>>> las = lasio.examples.open('sample.las')
>>> las.to_csv(stdout)
DEPT,DT,RHOB,NPHI,SFLU,SFLA,ILM,ILD
M,US/M,K/M3,V/V,OHMM,OHMM,OHMM,OHMM
1670.0,123.45,2550.0,0.45,123.45,123.45,110.2,105.6
1669.875,123.45,2550.0,0.45,123.45,123.45,110.2,105.6
1669.75,123.45,2550.0,0.45,123.45,123.45,110.2,105.6
```

There are options for putting the units together with mnemonics:

```
>>> las.to_csv(stdout, units_loc='[]')
DEPT [M],DT [US/M],RHOB [K/M3],NPHI [V/V],SFLU [OHMM],SFLA [OHMM],ILM [OHMM],ILD␣
↪[OHMM]
1670.0,123.45,2550.0,0.45,123.45,123.45,110.2,105.6
1669.875,123.45,2550.0,0.45,123.45,123.45,110.2,105.6
1669.75,123.45,2550.0,0.45,123.45,123.45,110.2,105.6
```

Or leaving things out altogether:

```
>>> las.to_csv(stdout, mnemonics=False, units=False)
1670.0,123.45,2550.0,0.45,123.45,123.45,110.2,105.6
1669.875,123.45,2550.0,0.45,123.45,123.45,110.2,105.6
1669.75,123.45,2550.0,0.45,123.45,123.45,110.2,105.6
```

7.2 Excel spreadsheet (XLSX)

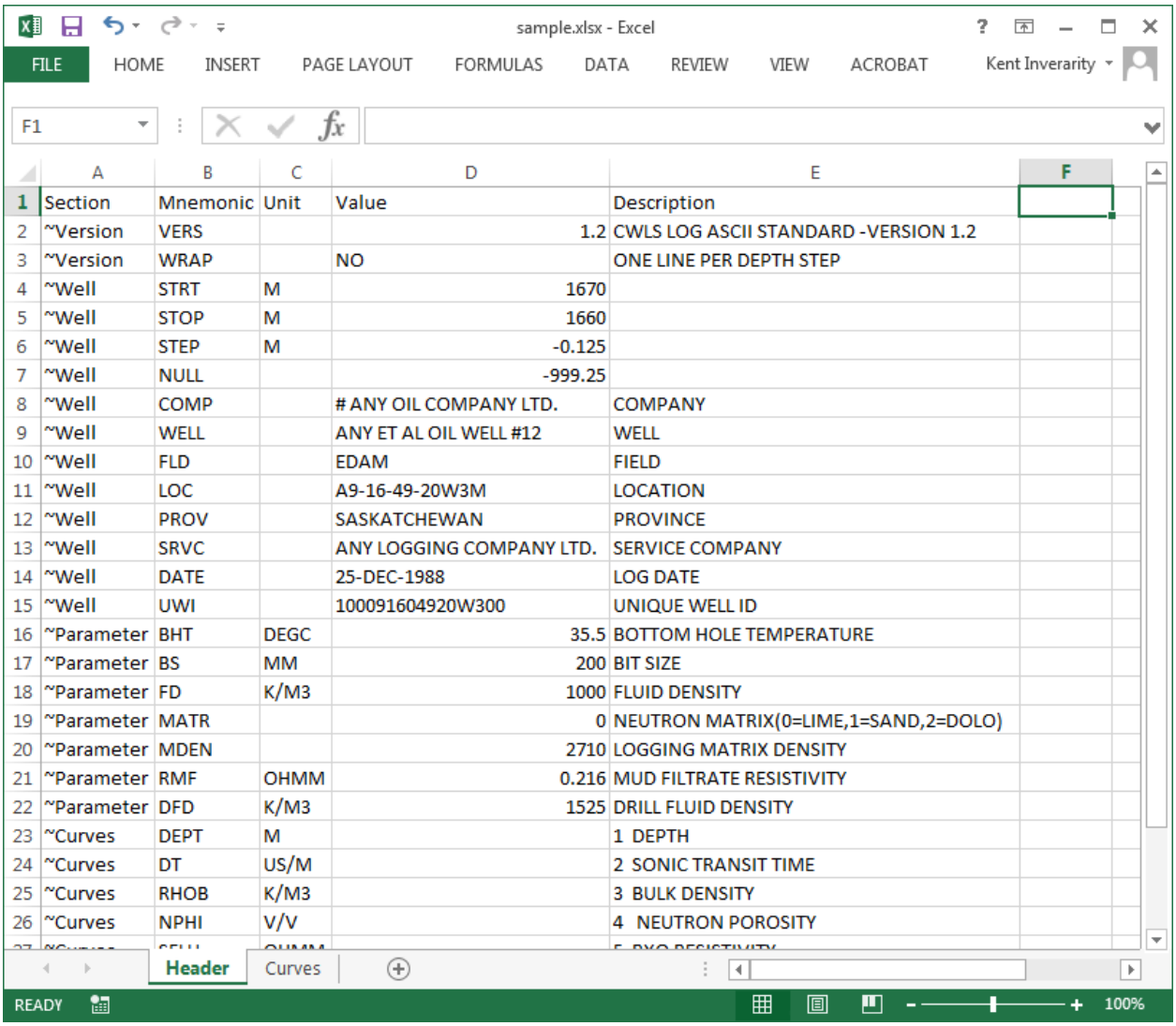
You can easily convert LAS files into Excel, retaining the header information. If we are working in Python, you export like this:

```
>>> las.to_excel('sample.xlsx')
```

You will need to have openpyxl installed (`$ pip install openpyxl`).

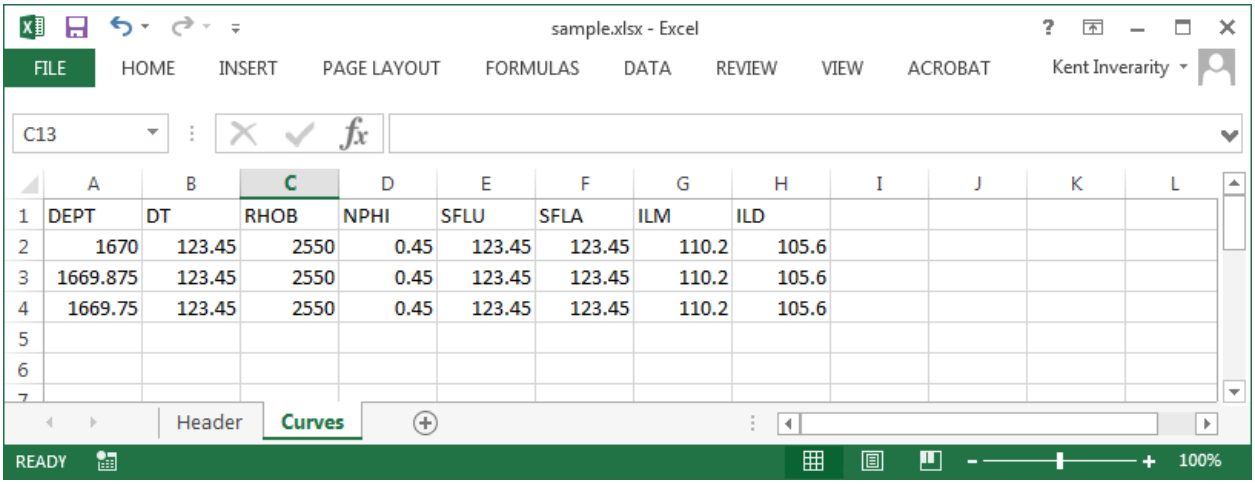
7.2.1 Format of exported Excel file

The exported spreadsheet has two sheets named "Header" and "Curves". The "Header" sheet has five columns named "Section", "Mnemonic", "Unit", "Value", and "Description", containing the information from all the sections in the header.



	A	B	C	D	E	F
1	Section	Mnemonic	Unit	Value	Description	
2	~Version	VERS		1.2	CWLS LOG ASCII STANDARD -VERSION 1.2	
3	~Version	WRAP		NO	ONE LINE PER DEPTH STEP	
4	~Well	STRT	M	1670		
5	~Well	STOP	M	1660		
6	~Well	STEP	M	-0.125		
7	~Well	NULL		-999.25		
8	~Well	COMP		# ANY OIL COMPANY LTD.	COMPANY	
9	~Well	WELL		ANY ET AL OIL WELL #12	WELL	
10	~Well	FLD		EDAM	FIELD	
11	~Well	LOC		A9-16-49-20W3M	LOCATION	
12	~Well	PROV		SASKATCHEWAN	PROVINCE	
13	~Well	SRVC		ANY LOGGING COMPANY LTD.	SERVICE COMPANY	
14	~Well	DATE		25-DEC-1988	LOG DATE	
15	~Well	UWI		100091604920W300	UNIQUE WELL ID	
16	~Parameter	BHT	DEGC	35.5	BOTTOM HOLE TEMPERATURE	
17	~Parameter	BS	MM	200	BIT SIZE	
18	~Parameter	FD	K/M3	1000	FLUID DENSITY	
19	~Parameter	MATR		0	NEUTRON MATRIX(0=LIME,1=SAND,2=DOLO)	
20	~Parameter	MDEN		2710	LOGGING MATRIX DENSITY	
21	~Parameter	RMF	OHMM	0.216	MUD FILTRATE RESISTIVITY	
22	~Parameter	DFD	K/M3	1525	DRILL FLUID DENSITY	
23	~Curves	DEPT	M		1 DEPTH	
24	~Curves	DT	US/M		2 SONIC TRANSIT TIME	
25	~Curves	RHOB	K/M3		3 BULK DENSITY	
26	~Curves	NPHI	V/V		4 NEUTRON POROSITY	

The "Curves" sheet contains the data as a table, with the curve mnemonics as a header row.



	A	B	C	D	E	F	G	H
1	DEPT	DT	RHOB	NPHI	SFLU	SFLA	ILM	ILD
2	1670	123.45	2550	0.45	123.45	123.45	110.2	105.6
3	1669.875	123.45	2550	0.45	123.45	123.45	110.2	105.6
4	1669.75	123.45	2550	0.45	123.45	123.45	110.2	105.6
5								
6								

7.2.2 Script interfaces

7.2.2.1 Single file

```
$ las2excel --help
usage: Convert LAS file to XLSX [-h] LAS_filename XLSX_filename

positional arguments:
  LAS_filename
  XLSX_filename

optional arguments:
  -h, --help     show this help message and exit

$ las2excel sample.las sample.xlsx
```

7.2.2.2 Multiple files (`las2excelbulk`)

The better script to use is `las2excelbulk`:

```
$ las2excelbulk --help
usage: Convert LAS files to XLSX [-h] [-g GLOB] [-r] [-i] path

positional arguments:
  path

optional arguments:
  -h, --help            show this help message and exit
  -g GLOB, --glob GLOB  Match LAS files with this pattern (default: *.las)
  -r, --recursive       Recurse through subfolders. (default: False)
  -i, --ignore-header-errors
                        Ignore header section errors. (default: False)
```

Here is the command to create Excel versions of all the LAS files contained within the folder `test_folder`, and any sub-folders:

Notice that some LAS files raised exceptions (in this case, `ValueError`) and were not converted. In some cases these will relate to errors in the header sections:

```
$ las2excelbulk.exe -r .
Converting .\4424\PN31769.LAS -> .\4424\pn31769.xlsx
Converting .\4424\PN31769L.LAS -> .\4424\pn31769l.xlsx
Converting .\4424\PN31769R.LAS -> .\4424\pn31769r.xlsx
Converting .\4428\pn31769.las -> .\4428\pn31769.xlsx
Failed to convert file. Error message:
Traceback (most recent call last):
  File "c:\program files (x86)\misc\kentcode\lasio\lasio\reader.py", line 366, in␣
↪parse_header_section
    values = read_line(line)
  File "c:\program files (x86)\misc\kentcode\lasio\lasio\reader.py", line 522, in␣
↪read_line
    return read_header_line(*args, **kwargs)
  File "c:\program files (x86)\misc\kentcode\lasio\lasio\reader.py", line 548, in␣
↪read_header_line
    mdict = m.groupdict()
AttributeError: 'NoneType' object has no attribute 'groupdict'

During handling of the above exception, another exception occurred:

Traceback (most recent call last):
  File "c:\program files (x86)\misc\kentcode\lasio\lasio\excel.py", line 133, in main_
↪bulk
    l = las.LASFile(lasfn, ignore_header_errors=args.ignore_header_errors)
  File "c:\program files (x86)\misc\kentcode\lasio\lasio\las.py", line 77, in __init__
    self.read(file_ref, **read_kwargs)
  File "c:\program files (x86)\misc\kentcode\lasio\lasio\las.py", line 156, in read
    ignore_header_errors=ignore_header_errors)
  File "c:\program files (x86)\misc\kentcode\lasio\lasio\las.py", line 110, in add_
↪section
    **sect_kws)
  File "c:\program files (x86)\misc\kentcode\lasio\lasio\reader.py", line 375, in␣
↪parse_header_section
    raise exceptions.LASHeaderError(message)
lasio.exceptions.LASHeaderError: Line #21 - failed in ~Well Information section on␣
↪line:
PN        PERMIT NUMBER: 31769AttributeError: 'NoneType' object has no attribute
↪'groupdict'

Converting .\4526\PENRICE.LAS -> .\4526\penrice.xlsx
```

But in this case I'm happy to lose that single corrupted line in the header in the conversion. In order to force lasio to ignore the error and continue to convert the file, use the `--ignore-header-errors` flag (`-i` for short):

```
$ las2excelbulk.exe -r -i .
Converting .\4424\PN31769.LAS -> .\4424\pn31769.xlsx
Converting .\4424\PN31769L.LAS -> .\4424\pn31769l.xlsx
Converting .\4424\PN31769R.LAS -> .\4424\pn31769r.xlsx
Converting .\4428\pn31769.las -> .\4428\pn31769.xlsx
Line #21 - failed in ~Well Information section on line:
PN        PERMIT NUMBER: 31769AttributeError: 'NoneType' object has no attribute
↪'groupdict'
Converting .\4526\PENRICE.LAS -> .\4526\penrice.xlsx
```

lasio still reports the problem, but ignores it and continues the conversion of the file.

CHAPTER 8

Building a LAS file from scratch

When you create a *lasio.LASFile* from scratch, it comes with some default metadata:

```
>>> import lasio
>>> las = lasio.LASFile()
>>> las.header
{'Version': [HeaderItem(mnemonic="VERS", unit="", value="2.0", descr="CWLS log ASCII␣
↪Standa"),
 HeaderItem(mnemonic="WRAP", unit="", value="NO", descr="One line per depth ste"),
 HeaderItem(mnemonic="DLM", unit="", value="SPACE", descr="Column Data Section ")],
'Well': [HeaderItem(mnemonic="STRT", unit="m", value="nan", descr="START DEPTH"),
 HeaderItem(mnemonic="STOP", unit="m", value="nan", descr="STOP DEPTH"),
 HeaderItem(mnemonic="STEP", unit="m", value="nan", descr="STEP"),
 HeaderItem(mnemonic="NULL", unit="", value="-9999.25", descr="NULL VALUE"),
 HeaderItem(mnemonic="COMP", unit="", value="", descr="COMPANY"),
 HeaderItem(mnemonic="WELL", unit="", value="", descr="WELL"),
 HeaderItem(mnemonic="FLD", unit="", value="", descr="FIELD"),
 HeaderItem(mnemonic="LOC", unit="", value="", descr="LOCATION"),
 HeaderItem(mnemonic="PROV", unit="", value="", descr="PROVINCE"),
 HeaderItem(mnemonic="CNTY", unit="", value="", descr="COUNTY"),
 HeaderItem(mnemonic="STAT", unit="", value="", descr="STATE"),
 HeaderItem(mnemonic="CTRY", unit="", value="", descr="COUNTRY"),
 HeaderItem(mnemonic="SRVC", unit="", value="", descr="SERVICE COMPANY"),
 HeaderItem(mnemonic="DATE", unit="", value="", descr="DATE"),
 HeaderItem(mnemonic="UWI", unit="", value="", descr="UNIQUE WELL ID"),
 HeaderItem(mnemonic="API", unit="", value="", descr="API NUMBER")],
'Curves': [],
'Parameter': [],
'Other': ''}
```

In our case, let's set the correct date:

```
>>> from datetime import datetime
>>> las.well.DATE = datetime.today().strftime('%Y-%m-%d %H:%M:%S')
```

And add some new header fields:

```
>>> las.params['ENG'] = lasio.HeaderItem('ENG', value='Kent Inverarity')
>>> las.params['LMF'] = lasio.HeaderItem('LMF', value='GL')
>>> las.other = 'Example of how to create a LAS file from scratch using lasio'
```

We will invent some data for a curve:

```
>>> import numpy as np
>>> depths = np.arange(10, 50, 0.5)
>>> synth = np.log10(depths)*5+np.random.random(len(depths))
>>> synth[:8] = np.nan
```

. . . add these to the LASFile object:

```
>>> las.add_curve('DEPT', depths, unit='m')
>>> las.add_curve('SYNTH', synth, descr='fake data')
```

And write the result to files:

```
>>> las.write('scratch_v1.2.las', version=1.2)
>>> las.write('scratch_v2.las', version=2)
```

Here is the resulting scratch_v1.2.las:

```
~Version ------------------------------------------------
VERS.   1.2 : CWLS LOG ASCII STANDARD - VERSION 1.2
WRAP.    NO : One line per depth step
DLM . SPACE : Column Data Section Delimiter
~Well ---------------------------------------------------
STRT.m           10.0 : START DEPTH
STOP.m           49.5 : STOP DEPTH
STEP.m            0.5 : STEP
NULL.        -9999.25 : NULL VALUE
COMP.         COMPANY :
WELL.            WELL :
FLD .           FIELD :
LOC .        LOCATION :
PROV.        PROVINCE :
CNTY.          COUNTY :
STAT.           STATE :
CTRY.         COUNTRY :
SRVC. SERVICE COMPANY :
DATE.            DATE : 2017-11-04 15:33:20.963287
UWI .  UNIQUE WELL ID :
API .      API NUMBER :
~Curves -------------------------------------------------
DEPT .m  :
SYNTH.   : fake data
~Params -------------------------------------------------
ENG. Kent Inverarity :
LMF.              GL :
~Other --------------------------------------------------
Example of how to create a LAS file from scratch using lasio
~ASCII --------------------------------------------------
         10   -9999.25
       10.5   -9999.25
         11   -9999.25
       11.5   -9999.25
```

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```
        12   -9999.25
      12.5   -9999.25
        13   -9999.25
      13.5   -9999.25
        14      5.799
      14.5     6.3938
        15     6.4122
      15.5     6.4605
        16     6.9518
      16.5      6.567
        17     6.3816
      17.5     6.2872
        18     6.4336
      18.5     7.0252
        19     6.7988
      19.5     6.7172
        20     6.6929
      20.5     7.0971
        21      7.145
      21.5     6.7192
        22     7.6034
      22.5     7.3078
        23     7.2213
      23.5      7.668
        24      7.853
      24.5     7.4073
        25     7.4238
      25.5     7.9173
        26     7.1282
      26.5     7.4131
        27     7.8014
      27.5      7.348
        28        7.9
      28.5     7.6294
        29     8.1244
      29.5     7.9835
        30     7.4759
      30.5     8.3766
        31     7.4717
      31.5     7.6432
        32     8.2327
      32.5     7.6541
        33     8.4481
      33.5     7.8811
        34     8.2332
      34.5     8.4302
        35     7.7218
      35.5       8.71
        36     8.3965
      36.5     8.4355
        37     8.6836
      37.5     8.2236
        38     8.4997
      38.5     8.6656
        39     8.8295
      39.5     8.1707
        40     8.9034
```

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```
        40.5      8.681
          41     8.1698
        41.5     8.3001
          42     9.0266
        42.5     8.4398
          43     8.7562
        43.5     8.2673
          44     8.4682
        44.5     8.5801
          45     8.9065
        45.5     8.8392
          46      8.661
        46.5     9.2355
          47     9.0468
        47.5     8.8249
          48     9.0298
        48.5     8.6864
          49     8.5745
        49.5     8.6143
```

and scratch_v2.las:

```
~Version ------------------------------------------------
VERS.   2.0 : CWLS log ASCII Standard -VERSION 2.0
WRAP.    NO : One line per depth step
DLM . SPACE : Column Data Section Delimiter
~Well ---------------------------------------------------
STRT.m                      10.0 : START DEPTH
STOP.m                      49.5 : STOP DEPTH
STEP.m                       0.5 : STEP
NULL.                   -9999.25 : NULL VALUE
COMP.                            : COMPANY
WELL.                            : WELL
FLD .                            : FIELD
LOC .                            : LOCATION
PROV.                            : PROVINCE
CNTY.                            : COUNTY
STAT.                            : STATE
CTRY.                            : COUNTRY
SRVC.                            : SERVICE COMPANY
DATE. 2017-11-04 15:33:20.963287 : DATE
UWI .                            : UNIQUE WELL ID
API .                            : API NUMBER
~Curves -------------------------------------------------
DEPT .m  :
SYNTH.   : fake data
~Params -------------------------------------------------
ENG. Kent Inverarity :
LMF.              GL :
~Other --------------------------------------------------
Example of how to create a LAS file from scratch using lasio
~ASCII --------------------------------------------------
         10   -9999.25
       10.5   -9999.25
         11   -9999.25
       11.5   -9999.25
         12   -9999.25
```

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```
        12.5   -9999.25
          13   -9999.25
        13.5   -9999.25
          14      5.799
        14.5     6.3938
          15     6.4122
        15.5     6.4605
          16     6.9518
        16.5      6.567
          17     6.3816
        17.5     6.2872
          18     6.4336
        18.5     7.0252
          19     6.7988
        19.5     6.7172
          20     6.6929
        20.5     7.0971
          21      7.145
        21.5     6.7192
          22     7.6034
        22.5     7.3078
          23     7.2213
        23.5      7.668
          24      7.853
        24.5     7.4073
          25     7.4238
        25.5     7.9173
          26     7.1282
        26.5     7.4131
          27     7.8014
        27.5      7.348
          28        7.9
        28.5     7.6294
          29     8.1244
        29.5     7.9835
          30     7.4759
        30.5     8.3766
          31     7.4717
        31.5     7.6432
          32     8.2327
        32.5     7.6541
          33     8.4481
        33.5     7.8811
          34     8.2332
        34.5     8.4302
          35     7.7218
        35.5       8.71
          36     8.3965
        36.5     8.4355
          37     8.6836
        37.5     8.2236
          38     8.4997
        38.5     8.6656
          39     8.8295
        39.5     8.1707
          40     8.9034
        40.5      8.681
```

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```
        41      8.1698
      41.5      8.3001
        42      9.0266
      42.5      8.4398
        43      8.7562
      43.5      8.2673
        44      8.4682
      44.5      8.5801
        45      8.9065
      45.5      8.8392
        46       8.661
      46.5      9.2355
        47      9.0468
      47.5      8.8249
        48      9.0298
      48.5      8.6864
        49      8.5745
      49.5      8.6143
```

CHAPTER 9

Character encodings

There are four options:

1. Specify the encoding (internally lasio uses the open function from codecs which is part of the standard library):

```
>>> las = lasio.read('example.las', encoding='windows-1252')
```

2. Do nothing. By default *lasio.read()* uses the keyword argument `autodetect_encoding=True`. This will try to open the file with a few different encodings, like 'ascii', 'windows-1252', and 'latin-1'. The first one to raise no `UnicodeDecodeError` exceptions will be used.

This may still result in an error, or incorrectly decoded characters.

3. Install a package like cChardet (faster) or chardet (slower) to automatically detect the character encoding. If these packages are installed then lasio will use them by default:

```
>>> import logging
>>> logging.basicConfig()
>>> logging.getLogger().setLevel(logging.DEBUG)
>>> las = lasio.read('encodings_utf8.las')
DEBUG:lasio.reader:get_encoding Using cchardet
DEBUG:lasio.reader:cchardet method detected encoding of UTF-8 at confidence 0.
↪9900000095367432
INFO:lasio.reader:Opening encodings_utf8.las as UTF-8 and treating errors with
↪"replace"
DEBUG:lasio.las:n_curves=8 ncols=8
DEBUG:lasio.las:set_data data.shape = (3, 8)
DEBUG:lasio.las:set_data self.data.shape = (3, 8)
```

This may still result in an error, or incorrectly decoded characters.

If you are certain that you have no "extended characters" (or that you don't care), you can easily speed up lasio's performance by using:

```
>>> try:
...     las = lasio.read('example.las', autodetect_encoding=False)
```

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```
... except UnicodeDecodeError:
...     continue
```

CHAPTER 10

Docstrings for the lasio package

10.1 Reading LAS files

lasio.**read**(*file_ref*, ***kwargs*)

Read a LAS file.

Note that only versions 1.2 and 2.0 of the LAS file specification are currently supported.

Parameters **file_ref** (*file-like object, str*) – either a filename, an open file object, or a string containing the contents of a file.

Returns a *lasio.LASFile* object representing the file – see above

There are a number of optional keyword arguments that can be passed to this function that control how the LAS file is opened and parsed. Any of the keyword arguments from the below functions can be used here:

- *lasio.reader.open_with_codecs()* - manage issues relate to character encodings
- lasio.las.LASFile.read() - control how NULL values and errors are handled during parsing

class lasio.**LASFile**(*file_ref=None*, ***read_kwargs*)

LAS file object.

Keyword Arguments **file_ref** (*file-like object, str*) – either a filename, an open file object, or a string containing the contents of a file.

See these routines for additional keyword arguments you can use when reading in a LAS file:

- *lasio.reader.open_with_codecs()* - manage issues relate to character encodings
- *lasio.LASFile.read()* - control how NULL values and errors are handled during parsing

encoding

the character encoding used when reading the file in from disk

Type str or None

LASFile.**read**(*file_ref*, *ignore_data=False*, *read_policy='default'*, *null_policy='strict'*, *ignore_header_errors=False*, *ignore_comments=('#',)*, *mnemonic_case='upper'*, *index_unit=None*, *remove_data_line_filter='#'*, ***kwargs*)

Read a LAS file.

Parameters **file_ref** (*file-like object, str*) – either a filename, an open file object, or a string containing the contents of a file.

Keyword Arguments

- **null_policy** (*str or list*) – see http://lasio.readthedocs.io/en/latest/data-section.html#handling-invalid-data-indicators-automatically
- **ignore_data** (*bool*) – if True, do not read in any of the actual data, just the header metadata. False by default.
- **ignore_header_errors** (*bool*) – ignore LASHeaderErrors (False by default)
- **ignore_comments** (*tuple/str*) – ignore comments beginning with characters e.g. `("#", '"')` in header sections
- **mnemonic_case** (*str*) – 'preserve': keep the case of HeaderItem mnemonics 'upper': convert all HeaderItem mnemonics to uppercase 'lower': convert all HeaderItem mnemonics to lowercase
- **index_unit** (*str*) – Optionally force-set the index curve's unit to "m" or "ft"
- **remove_data_line_filter** (*str, func*) – string or function for removing/ignoring lines in the data section e.g. a function which accepts a string (a line from the data section) and returns either True (do not parse the line) or False (parse the line). If this argument is a string it will instead be converted to a function which rejects all lines starting with that value e.g. `"#"` will be converted to `lambda line: line.strip().startswith("#")`

See *lasio.reader.open_with_codecs()* for additional keyword arguments which help to manage issues relate to character encodings.

lasio.**open_file**(*file_ref*, ***encoding_kwargs*)

Open a file if necessary.

If `autodetect_encoding=True` then either `cchardet` or `chardet` needs to be installed, or else an `ImportError` will be raised.

Parameters **file_ref** (*file-like object, str*) – either a filename, an open file object, or a string containing the contents of a file.

See *lasio.reader.open_with_codecs()* for keyword arguments that can be used here.

Returns tuple of an open file-like object, and the encoding that was used to decode it (if it were read from disk).

lasio.reader.**open_with_codecs**(*filename*, *encoding=None*, *encoding_errors='replace'*, *autodetect_encoding=True*, *autodetect_encoding_chars=4000*)

Read Unicode data from file.

Parameters **filename** (*str*) – path to file

Keyword Arguments

- **encoding** (*str*) – character encoding to open file_ref with, using `io.open()`.
- **encoding_errors** (*str*) – 'strict', 'replace' (default), 'ignore' - how to handle errors with encodings (see this section of the standard library's `codecs` module for more information)

- **autodetect_encoding** (*str or bool*) – default True to use chardet/cchardet to detect encoding. Note if set to False several common encodings will be tried but chardet won't be used.
- **autodetect_encoding_chars** (*int/None*) – number of chars to read from LAS file for auto-detection of encoding.

Returns a unicode or string object

This function is called by `lasio.reader.open_file()`.

`lasio.reader.`**`get_encoding`**(*auto*, *raw*)

Automatically detect character encoding.

Parameters

- **auto** (*str*) – auto-detection of character encoding - can be either 'chardet', 'cchardet', False, or True (the latter will pick the fastest available option)
- **raw** (*bytes*) – array of bytes to detect from

Returns A string specifying the character encoding.

`lasio.reader.`**`read_file_contents`**(*file_obj*, *regexp_subs*, *value_null_subs*, *ignore_data=False*, *remove_line_filter='#'*)

Read file contents into memory.

Parameters **file_obj** (*open file-like object*) –

Keyword Arguments

- **null_subs** (*bool*) – True will substitute `numpy.nan` for invalid values
- **ignore_data** (*bool*) – if True, do not read in the numerical data in the ~ASCII section
- **remove_line_filter** (*str, func*) – string or function for removing/ignoring lines in the data section e.g. a function which accepts a string (a line from the data section) and returns either True (do not parse the line) or False (parse the line). If this argument is a string it will instead be converted to a function which rejects all lines starting with that value e.g. `"#"` will be converted to `lambda line: line.strip().startswith("#")`

Returns OrderedDict

I think of the returned dictionary as a "raw section". The keys are the first line of the LAS section, including the tilde. Each value is a dict with either:

```
{"section_type": "header",
 "title": str,                # title of section (including the ~)
 "lines": [str, ],            # a list of the lines from the lAS file
 "line_nos": [int, ]          # line nos from the original file
 }
```

or:

```
{"section_type": "data",
 "title": str,               # title of section (including the ~)
 "start_line": int,          # location of data section (the title line)
 "ncols": int,               # no. of columns on first line of data,
 "array": ndarray            # 1-D numpy.ndarray,
 }
```

`LASFile.`**`match_raw_section`**(*pattern*, *re_func='match'*, *flags=<RegexFlag.IGNORECASE: 2>*)

Find raw section with a regular expression.

Parameters **pattern** (*str*) – regular expression (you need to include the tilde)

Keyword Arguments

- **re_func** (*str*) – either "match" or "search", see python `re` module.
- **flags** (*int*) – flags for `re.compile()`

Returns dict

Intended for internal use only.

lasio.reader.**read_data_section_iterative**(*file_obj*, *line_nos*, *regexp_subs*, *value_null_subs*, *remove_line_filter*)

Read data section into memory.

Parameters

- **file_obj** – file-like object open for reading at the beginning of the section
- **line_nos** (*tuple*) – the first and last line no of the section to read
- **regexp_subs** (*list*) – each item should be a tuple of the pattern and substitution string for a call to re.sub() on each line of the data section. See defaults.py READ_SUBS and NULL_SUBS for examples.
- **value_null_subs** (*list*) – list of numerical values to be replaced by numpy.nan values.
- **remove_line_filter** (*str or func*) – string or function for removing/ignoring lines in the data section e.g. a function which accepts a string (a line from the data section) and returns either True (do not parse the line) or False (parse the line). If this argument is a string it will instead be converted to a function which rejects all lines starting with that value e.g. `"#"` will be converted to `lambda line: line.strip().startswith("#")`

Returns A 1-D numpy ndarray.

lasio.reader.**get_substitutions**(*read_policy*, *null_policy*)

Parse read and null policy definitions into a list of regexp and value substitutions.

Parameters

- **read_policy** (*str, list, or substitution*) – either (1) a string defined in defaults.READ_POLICIES; (2) a list of substitutions as defined by the keys of defaults.READ_SUBS; or (3) a list of actual substitutions similar to the values of defaults.READ_SUBS. You can mix (2) and (3) together if you want.
- **null_policy** (*str, list, or sub*) – as for read_policy but for defaults.NULL_POLICIES and defaults.NULL_SUBS

Returns regexp_subs, value_null_subs, version_NULL - two lists and a bool. The first list is pairs of regexp patterns and substrs, and the second list is just a list of floats or integers. The bool is whether or not 'NULL' was located as a substitution.

class lasio.reader.**SectionParser**(*title*, *version=1.2*)

Parse lines from header sections.

Parameters **title** (*str*) – title line of section. Used to understand different order formatting across the special sections ~C, ~P, ~W, and ~V, depending on version 1.2 or 2.0.

Keyword Arguments **version** (*float*) – version to parse according to. Default is 1.2.

lasio.reader.**read_header_line**(*line*, *pattern=None*, *section_name=None*)

Read a line from a LAS header section.

The line is parsed with a regular expression – see LAS file specs for more details, but it should basically be in the format:

```
name.unit       value : descr
```

Parameters

- **line** (*str*) – line from a LAS header section
- **section_name** (*str*) – Name of the section the 'line' is from. The default
- **is None.** (*value*) –

Returns A dictionary with keys 'name', 'unit', 'value', and 'descr', each containing a string as value.

class lasio.**HeaderItem**(*mnemonic=''*, *unit=''*, *value=''*, *descr=''*, *data=None*)
Dictionary/namedtuple-style object for a LAS header line.

Parameters

- **mnemonic** (*str*) – the mnemonic
- **unit** (*str*) – the unit (no whitespace!)
- **value** (*str*) – value
- **descr** (*str*) – description

These arguments are available for use as either items or attributes of the object.

HeaderItem.**set_session_mnemonic_only**(*value*)
Set the mnemonic for session use.

See source comments for lasio.HeaderItem.__init__ for a more in-depth explanation.

class lasio.**CurveItem**(*mnemonic=''*, *unit=''*, *value=''*, *descr=''*, *data=None*)
Dictionary/namedtuple-style object for a LAS curve.

See lasio.HeaderItem` for the (keyword) arguments.

Keyword Arguments **data** (*array-like, 1-D*) – the curve's data.

class lasio.**SectionItems**(**args*, ***kwargs*)
Variant of a list which is used to represent a LAS section.

10.2 Reading data

LASFile.**__getitem__**(*key*)
Provide access to curve data.

Parameters **key** (*str, int*) – either a curve mnemonic or the column index.

Returns 1D numpy.ndarray (the data for the curve)

LASFile.**__setitem__**(*key*, *value*)
Append a curve.

Parameters

- **key** (*str*) – the curve mnemonic
- **value** (*1D data or CurveItem*) – either the curve data, or a CurveItem

See *lasio.LASFile.append_curve_item()* or *lasio.LASFile.append_curve()* for more details.

LASFile.**get_curve**(*mnemonic*)
Return CurveItem object.

Parameters **mnemonic** (*str*) – the name of the curve

Returns *lasio.CurveItem* (not just the data array)

LASFile.**keys**()
Return curve mnemonics.

LASFile.**values**()
Return data for each curve.

LASFile.**items**()
Return mnemonics and data for all curves.

LASFile.**df**()
Return data as a `pandas.DataFrame` structure.

The first Curve of the LASFile object is used as the pandas DataFrame's index.

LASFile.**version**
Header information from the Version (~V) section.

Returns *lasio.SectionItems* object.

LASFile.**well**
Header information from the Well (~W) section.

Returns *lasio.SectionItems* object.

LASFile.**curves**
Curve information and data from the Curves (~C) and data section..

Returns *lasio.SectionItems* object.

LASFile.**curvesdict**
Curve information and data from the Curves (~C) and data section..

Returns dict

LASFile.**params**
Header information from the Parameter (~P) section.

Returns *lasio.SectionItems* object.

LASFile.**other**
Header information from the Other (~O) section.

Returns str

LASFile.**index**
Return data from the first column of the LAS file data (depth/time).

LASFile.**depth_m**
Return the index as metres.

LASFile.**depth_ft**
Return the index as feet.

LASFile.**data**

LASFile.**stack_curves**(*mnemonic*, *sort_curves=True*)
Stack multi-channel curve data to a numpy 2D ndarray. Provide a stub name (prefix shared by all curves that will be stacked) or a list of curve mnemonic strings.

Keyword Arguments

- **mnemonic** (*str or list*) – Supply the first several characters of the channel set to be stacked. Alternatively, supply a list of the curve names (mnemonics strings) to be stacked.
- **sort_curves** (*bool*) – Natural sort curves based on mnemonic prior to stacking.

Returns 2-D numpy array

10.3 Modifying data

LASFile.**set_data**(*array_like*, *names=None*, *truncate=False*)
Set the data for the LAS; actually sets data on individual curves.

Parameters **array_like** (array_like or pandas.DataFrame) – 2-D data array

Keyword Arguments

- **names** (*list, optional*) – used to replace the names of the existing *lasio.CurveItem* objects.
- **truncate** (*bool*) – remove any columns which are not included in the Curves (~C) section.

Note: you can pass a pandas.DataFrame to this method.

LASFile.**set_data_from_df**(*df*, ***kwargs*)
Set the LAS file data from a pandas.DataFrame.

Parameters **df** (*pandas.DataFrame*) – curve mnemonics are the column names. The depth column for the curves must be the index of the DataFrame.

Keyword arguments are passed to *lasio.LASFile.set_data()*.

LASFile.**append_curve**(*mnemonic*, *data*, *unit=''*, *descr=''*, *value=''*)
Add a curve.

Parameters

- **mnemonic** (*str*) – the curve mnemonic
- **data** (*1D ndarray*) – the curve data

Keyword Arguments

- **unit** (*str*) – curve unit
- **descr** (*str*) – curve description
- **value** (*int/float/str*) – value e.g. API code.

LASFile.**insert_curve**(*ix*, *mnemonic*, *data*, *unit=''*, *descr=''*, *value=''*)
Insert a curve.

Parameters

- **ix** (*int*) – position to insert curve at i.e. 0 for start.
- **mnemonic** (*str*) – the curve mnemonic
- **data** (*1D ndarray*) – the curve data

Keyword Arguments

- **unit** (*str*) – curve unit
- **descr** (*str*) – curve description
- **value** (*int/float/str*) – value e.g. API code.

LASFile.**delete_curve**(*mnemonic=None*, *ix=None*)
Delete a curve.

Keyword Arguments

- **ix** (*int*) – index of curve in LASFile.curves.
- **mnemonic** (*str*) – mnemonic of curve.

The index takes precedence over the mnemonic.

LASFile.**append_curve_item**(*curve_item*)
Add a CurveItem.

Parameters **curve_item** (lasio.CurveItem) –

LASFile.**insert_curve_item**(*ix*, *curve_item*)
Insert a CurveItem.

Parameters

- **ix** (*int*) – position to insert CurveItem i.e. 0 for start
- **curve_item** (lasio.CurveItem) –

10.4 Writing data out

LASFile.**write**(*file_ref*, ***kwargs*)
Write LAS file to disk.

Parameters **file_ref** (*open file-like object or str*) – a file-like object opening for writing, or a filename.

All `**kwargs` are passed to *lasio.writer.write()* – please check the docstring of that function for more keyword arguments you can use here!

Examples

```
>>> import lasio
>>> las = lasio.read("tests/examples/sample.las")
>>> with open('test_output.las', mode='w') as f:
...     las.write(f, version=2.0)    # <-- this method
```

lasio.writer.**write**(*las*, *file_object*, *version=None*, *wrap=None*, *STRT=None*, *STOP=None*, *STEP=None*, *fmt='%.5f'*, *column_fmt=None*, *len_numeric_field=None*, *data_width=79*, *header_width=60*)
Write a LAS files.

Parameters

- **las** (*lasio.LASFile*) –
- **file_object** (*file-like object open for writing*) – output

- **version** (*float or None*) – version of written file, either 1.2 or 2. If this is None, `las.version.VERS.value` will be used.
- **wrap** (*bool or None*) – whether to wrap the output data section. If this is None, `las.version.WRAP.value` will be used.
- **STRT** (*float or None*) – value to use as STRT (note the data will not be clipped). If this is None, the data value in the first column, first row will be used.
- **STOP** (*float or None*) – value to use as STOP (note the data will not be clipped). If this is None, the data value in the first column, last row will be used.
- **STEP** (*float or None*) – value to use as STEP (note the data will not be resampled and/or interpolated). If this is None, the STEP will be estimated from the first two rows of the first column.
- **fmt** (*str*) – Python string formatting operator for numeric data to be used.
- **column_fmt** (*dict or None*) – use this to set a different format string for specific columns from the data ndarray. E.g. to use `'%.3f'` for the depth column and `'%.2f'` for all the other columns, you would use `fmt='%.2f', column_fmt={0: '%.3f'}`.
- **len_numeric_field** (*int*) – width of each numeric field column (must be greater than than all the formatted numeric values in the file).
- **data_width** (*79*) – width of data field in characters

Creating an output file is not the only side-effect of this function. It will also modify the STRT, STOP and STEP HeaderItems so that they correctly reflect the ~Data section's units and the actual first, last, and interval values.

However, passing a version to this write() function only changes the version of the object written to. Example: las.write(myfile, version=2). Lasio's internal-las-object version will remain separate and defined by las.version.VERS.value

You should avoid calling this function directly - instead use the *lasio.LASFile.write()* method.

lasio.writer.**get_formatter_function**(*order*, *left_width=None*, *middle_width=None*)

Create function to format a LAS header item for output.

Parameters **order** – format of item, either 'descr:value' or 'value:descr'

Keyword Arguments

- **left_width** (*int*) – number of characters to the left hand side of the first period
- **middle_width** (*int*) – total number of characters minus 1 between the first period from the left and the first colon from the left.

Returns A function which takes a header item (e.g. *lasio.HeaderItem*) as its single argument and which in turn returns a string which is the correctly formatted LAS header line.

lasio.writer.**get_section_order_function**(*section*, *version*, *order_definitions={1.2: {'Curves': ['value:descr'], 'Parameter': ['value:descr'], 'Version': ['value:descr'], 'Well': ['descr:value', ('value:descr', ['STRT', 'STOP', 'STEP', 'NULL', 'strt', 'stop', 'step', 'null'])]}, 2.0: {'Curves': ['value:descr'], 'Parameter': ['value:descr'], 'Version': ['value:descr'], 'Well': ['value:descr']}, 3.0: {'Curves': ['value:descr'], 'Parameter': ['value:descr'], 'Version': ['value:descr'], 'Well': ['value:descr']}}*)

Get a function that returns the order per the mnemonic and section.

Parameters

- **section** (*str*) – either 'well', 'params', 'curves', 'version'
- **version** (*float*) – either 1.2 and 2.0

Keyword Arguments **order_definitions** (*dict*) – see source of defaults.py for more information

Returns A function which takes a mnemonic (str) as its only argument, and in turn returns the order 'value:descr' or 'descr:value'.

lasio.writer.**get_section_widths**(*section_name*, *items*, *version*, *order_func*)
Find minimum section widths fitting the content in *items*.

Parameters

- **section_name** (*str*) – either 'version', 'well', 'curves', or 'params'
- **items** (SectionItems) – section items
- **version** (*float*) – either 1.2 or 2.0
- **order_func** (*func*) – see *lasio.writer.get_section_order_function()*

LASFile.**to_csv**(*file_ref*, *mnemonics=True*, *units=True*, *units_loc='line'*, ***kwargs*)
Export to a CSV file.

Parameters **file_ref** (*open file-like object or str*) – a file-like object opening for writing, or a filename.

Keyword Arguments

- **mnemonics** (*list, True, False*) – write mnemonics as a header line at the start. If list, use the supplied items as mnemonics. If True, use the curve mnemonics.
- **units** (*list, True, False*) – as for mnemonics.
- **units_loc** (*str or None*) – either 'line', '[]' or '()'. 'line' will put units on the line following the mnemonics (good for WellCAD). '[]' and '()' will put the units in either brackets or parentheses following the mnemonics, on the single header line (better for Excel)
- ****kwargs** – passed to csv.writer. Note that if lineterminator is **not** specified here, then it will be sent to csv.writer as lineterminator='\n'.

LASFile.**to_excel**(*filename*)
Export LAS file to a Microsoft Excel workbook.

This function will raise an ImportError if openpyxl is not installed.

Parameters **filename** (*str*) –

LASFile.**to_json**()

10.5 Custom exceptions

class lasio.exceptions.**LASDataError**
Error during reading of numerical data from LAS file.

class lasio.exceptions.**LASHeaderError**
Error during reading of header data from LAS file.

class lasio.exceptions.**LASUnknownUnitError**
Error of unknown unit in LAS file.

10.6 Test data

lasio.examples.**open**(*filename*, ***kwargs*)
Open an example LAS file from lasio's test suite.

Parameters **filename** (*str*) – forward-slash separated filename of a LAS file from lasio's test suite, starting from the "tests/examples" subfolder e.g. "1001178549.las" or "2.0/sample_2.0.las"

Other keyword arguments are passed to *lasio.LASFile*. If lasio has been installed locally from source, then the local version of the example file will be opened. If lasio has not been installed from source then the LAS file will be downloaded from GitHub.

Returns: LASFile object

lasio.examples.**open_github_example**(*filename*, *url_prefix='https://raw.githubusercontent.com/kinverarity1/lasio/master/t*
***kwargs*)
Open an example LAS file from lasio's test suite on GitHub

Parameters **filename** (*str*) – forward-slash separated filename of a LAS file from lasio's test suite, starting from the "tests/examples" subfolder e.g. "1001178549.las" or "2.0/sample_2.0.las"

Other keyword arguments are passed to *lasio.LASFile*.

Returns: LASFile object

lasio.examples.**open_local_example**(*filename*, ***kwargs*)
Open an example LAS file from lasio's test suite.

Parameters **filename** (*str*) – forward-slash separated filename of a LAS file from lasio's test suite, starting from the "tests/examples" subfolder e.g. "1001178549.las" or "2.0/sample_2.0.las"

Other keyword arguments are passed to *lasio.LASFile*. If lasio has not been installed from source then an exception will be raised.

Returns: LASFile object

lasio.examples.**get_local_examples_path**()
Return the path to the examples from lasio's test suite, if it is installed locally.

Returns: path as str.

CHAPTER 11

Contributing to lasio

lasio is an open source project released under the MIT License. It has grown over the years through the wonderful work of all these contributors:

- adamwulf
- ae3e
- ahjulstad
- eimerej
- dagrha
- dbhart
- dcslagel
- Fry484
- JustinGOSSES
- Jyhess
- kinverarity1
- kwinkunks
- MandarJKulkarni
- nasedil
- oliveirarodolfo
- roliveira
- trqmorgan
- VelizarVESSELINOV

Thank you also to everyone who has helped via email, in discussions on GitHub, and on software underground!

Your help is very welcome! No contribution is too small. You can help with the documentation, adding example notebooks, posting ideas or feature requests to GitHub, or by working on the code - or anything else!

11.1 Places you can help

- Please don't hesitate to open a GitHub issue for any problems you are having with lasio, or any ideas for improvements. There are templates to guide you in how to file a bug report, or a request for a new feature or improvement. If you are not sure whether your issue fits under these categories, please go ahead and raise one anyway!
- Please feel free to contribute suggested changes. The easiest method is to fork lasio on GitHub and submit a pull request against the "master" branch. Don't worry about getting all the details right, either way it's still the most convenient way for me or other maintainers to see your changes in context.
- Example LAS files: if you have an interesting/difficult/silly/standards-challenged LAS file (any version) you would be willing to share with me, please do so! Email it to me at kinverarity@hotmail.com. The more examples we can incorporate into lasio's regression testing, the better. If you have concerns about privacy, I'd suggest obfuscating with find-and-replace on various alpha (or numeric) characters before sending it on, and/or deleting any sensitive header lines.

11.2 How to make contributions

Contributions are always welcome to the code, documentation, or example notebooks. If you are making a contribution, please make sure you are working off the latest GitHub master. You will want to make your contributions in a branch taken from *master*, and then when you want to share your changes, you can publish them by "pushing" your branch to your GitHub fork of the lasio repository, and opening a PR (pull request) here.

First, create a fork of the lasio repository using the GitHub website. Then clone your fork locally to your computer:

```
$ git clone https://github.com/your-username/lasio
$ cd lasio
```

Your fork will be called the "origin" repository - you'll need to know this for when you push/pull changes to and from your computer.

11.2.1 Adding kinverarity1/lasio as "upstream"

Now also add the kinverarity1/lasio repository as the "upstream" repository. This is so that when other people make changes to kinverarity1/lasio, you can "pull" those changes into your local copy:

```
$ git remote add upstream https://github.com/kinverarity1/lasio
```

To update the *master* branch of the local copy you have of your fork from the "upstream" repository:

```
$ git checkout master
$ git pull upstream master
```

And to update the GitHub fork from your local copy:

```
$ git checkout master
$ git push origin master
```

11.2.2 Making sure you have necessary development dependencies

There are some additional packages you needing for running unit/regression tests (*pytest*) and formatting Python code (*black*). You can install these easily by using:

```
$ pip install --editable .[test]
```

11.2.3 Making changes to the code

First, start by making sure your local copy is using the latest copy of code from "upstream" master (see above). Then create a branch - you can call it whatever is meaningful to you. We switch to *master* so that your changes are relative to the latest copy of the code in *master*:

```
$ git checkout master
$ git checkout -b your-branch-name
Switched to a new branch 'your-branch-name'

(your-branch-name) $
```

Then you can make your changes. To test them, make sure you have an "editable" installation of lasio in your Python environment. Shift to the root folder of the repository and run:

```
$ pip install -e .
```

Then to run all the tests:

```
$ pytest
```

Before publishing your changes please make the code is formatted using black:

```
$ black .
```

Then you can push your changes to your fork:

```
$ git push origin your-branch-name
```

And follow the instructions on your fork's GitHub page to open a pull request (PR) for lasio!

11.2.4 Making changes to the documentation

Just as valuable as changes to the code, are changes or improvements to the Sphinx documentation! If you would like to help in this regard, you will need Sphinx and IPython installed:

```
$ pip install sphinx IPython sphinx_rtd_theme
```

Then create a new branch as above. The documentation is written in RestructuredText, and can be found in the *docs/source* subfolder of the lasio repository. If you have any changes, you can build a local copy of the HTML repository to test how it looks. First change into the docs folder:

```
$ cd docs
```

Then run this to generate a local copy of the HTML docs in the *build/html* folder:

```
$ make clean
$ make html
```

Once you are happy, please publish your branch and open a PR in the same way as above.

11.3 Email

Please feel free to email me at kinverarity@hotmail.com with any suggestions, criticisms, questions, example files.

11.4 Code of Conduct

11.4.1 Our Pledge

In the interest of fostering an open and welcoming environment, we as contributors and maintainers pledge to making participation in our project and our community a harassment-free experience for everyone, regardless of age, body size, disability, ethnicity, gender identity and expression, level of experience, nationality, personal appearance, race, religion, or sexual identity and orientation.

11.4.2 Our Standards

Examples of behavior that contributes to creating a positive environment include:

- Using welcoming and inclusive language
- Being respectful of differing viewpoints and experiences
- Gracefully accepting constructive criticism
- Focusing on what is best for the community
- Showing empathy towards other community members

Examples of unacceptable behavior by participants include:

- The use of sexualized language or imagery and unwelcome sexual attention or advances
- Trolling, insulting/derogatory comments, and personal or political attacks
- Public or private harassment
- Publishing others' private information, such as a physical or electronic address, without explicit permission
- Other conduct which could reasonably be considered inappropriate in a professional setting

11.4.3 Our Responsibilities

Project maintainers are responsible for clarifying the standards of acceptable behavior and are expected to take appropriate and fair corrective action in response to any instances of unacceptable behavior.

Project maintainers have the right and responsibility to remove, edit, or reject comments, commits, code, wiki edits, issues, and other contributions that are not aligned to this Code of Conduct, or to ban temporarily or permanently any contributor for other behaviors that they deem inappropriate, threatening, offensive, or harmful.

11.4.4 Scope

This Code of Conduct applies both within project spaces and in public spaces when an individual is representing the project or its community. Examples of representing a project or community include using an official project e-mail address, posting via an official social media account, or acting as an appointed representative at an online or offline event. Representation of a project may be further defined and clarified by project maintainers.

11.4.5 Enforcement

Instances of abusive, harassing, or otherwise unacceptable behavior may be reported by contacting the project team at kinverarity@hotmail.com. The project team will review and investigate all complaints, and will respond in a way that it deems appropriate to the circumstances. The project team is obliged to maintain confidentiality with regard to the reporter of an incident. Further details of specific enforcement policies may be posted separately.

Project maintainers who do not follow or enforce the Code of Conduct in good faith may face temporary or permanent repercussions as determined by other members of the project's leadership.

11.4.6 Attribution

This Code of Conduct is adapted from the Contributor Covenant version 1.4.

CHAPTER 12

List of changes

12.1 Version 0.29 (14 April 2021)

- Fix #404 (lasio changes STEP with imprecise floating-point number behaviour; #432)
- Add option `len_numeric_field=-1`, `lhs_spacer=" "`, and `spacer=" "` to writer.py:write (see #412; PR #418)
- Fix #271 (Read quoted strings in data section properly; #423)
- Fix #427 (Change null_policy to handle small non-zero values; #429)
- Fix #417 (Fix parsing for empty ~Other section; #430)
- Fix #402 (fixes issue when unit starts with dot; #403)
- Fix #395 (Update doc examples to reflect new HeaderItem repr; #410)
- Fix #426 (Update urllib.request to be the preferred urllib; #428)
- Add check for pushed tag version to version tests (#396)
- Update GitHub Action Python CI testing (#399, #400)
- Improve `las_items.py:HeaderItem.__repr__` truncation logic (#397)
- Remove codecs import (unused) and fix typo (#406)
- Exclude LAS files from GitHubs Language Stats (#411)
- Re-add try-except check around call to reader.read_data_section_iterative() (#401)
- Remove reader.py:read_file_contents - unused code (see #401; #393)
- Add test for timestring with colon in ~Well section (see #419 - PR #420)
- Fix SyntaxWarning in writer.py (#425)
- Add bugfix and feature request issue templates to GitHub repository
- Apply `black` code style to all Python files (#438, #398)

- Update demo notebook for using logging levels with current behaviour
- Update contributing guide (#437, #441)

12.2 Version 0.28 (12 September 2020)

- Major re-write of reader code working towards LAS 3.0 support (#327; #347, #345, #353, #355, #358, #367, #368, #369)
- Fix #377 (writing "None" as the value instead of ""; #377)
- Fix #373 (enable GitHub Actions CI testing on MacOS, Windows, Ubuntu; #374, #387)
- Fix #363 (parse composite units such as "1000 lbf" correctly; #390)
- Fix #319 (allow skipping comment lines in data sections; #391)
- Avoid unnecessary exceptions on reading LAS 3.0 data sections (#385)
- Fix broken ReadTheDocs build

12.3 Version 0.27 (4 September 2020)

- Fix #380 (install failed without git installed; #382)

12.4 Version 0.26 (31 August 2020)

- This is the final version which works on Python 2.7 (#364)
- Fix #333 (header lines not parsed when colon is in description; #335)
- Fix #359 (sections not found when leading whitespace in line; #360, #361)
- Fix #350 (bug with NULL; #352)
- Fix #339 (0.1IN not recognised as index unit; #340, #349)
- Fix #31 (add command-line script to convert between LAS versions; #329)
- Fix #75 (add Cyrillic variant for metres; #330)
- Fix #326 (Support header-only LAS files–don't lose the last header section before a missing ~A section)
- Improve documentation regarding deleting items and curves (#315, #325)
- Add deprecation markers (#331)
- Align json.dumps and LASFile.to_json() (#328)
- Fixes and updates to setup.py relating to the adoption of setuptools_scm (#312, #317, #318)
- Clean up and background changes related to future LAS 3.0 support: #334, #337, #338, #341, #342, #346, #348, #372

12.5 Version 0.25.1 (1 May 2020)

- Shift to setuptools_scm (#311)
- Fix #321 (EOF character causes error on read)
- Fix #182 (remove side-effect LASFile.write causing LASFile.version.VERS to change)
- Fix #310 (remove LASFile.metadata which was not working)

12.6 Version 0.25 (28 March 2020)

- Add stack_curves() method to allow joining a set of curves into a 2D array (issue #284, PR #293)
- Add lasio.examples module (#296)
- Fix #278 (leading zeroes were being stripped from API/UWI numbers)
- Fix #286 (error on trying to write a file with one row of data)
- Fix #258 (do not catch Ctrl+C when reading file)
- Fix #292 (improve error checking for when trying to write non-2D data)
- Fix #277 (allow pathlib objects to lasio.read)
- Fix #264 (allow periods in mnemonics to be retained in specific cases)
- Fix #201 (adjust descr parsing in ~P section to allow times in the descr, see PR #298)
- Fix #302 (change in str(datetime) handling)
- Fixes to JSON output (#300, #303)
- Fix #304 (add column_fmt argument to LASFile.write method)

12.7 Version 0.24

- Fix #256 (parse units in brackets and add index_unit kwarg)

12.8 Version 0.23

- Fix #259 (error when encoding missing from URL response headers)
- Fix #262 (broken build due to cchardet dependency)

12.9 Version 0.22

- Fix #252 (removing case sensitivity in index_unit checks)
- Fix #249 (fix bug producing df without converting to floats)
- Attempt to fix Lasso classification on GitHub

12.10 Version 0.21

- Fix #236 and #237 (can now read ASCII in ~Data section)
- Fix #239 (Petrel can't read lasio output)

12.11 Version 0.20

- Fix #233 (pickling error lost Curve.data during multiprocessing)
- Fix #226 (do not issue warning on empty ~Parameter section)
- Revised default behaviour to using null_policy='strict' (ref. #227)
- Fix #221 (depths > 10000 were being rounded by default)
- Fix #225 (file handle leaked if exception during parsing)

12.12 Version 0.19

- Fix #223 (critical version/installation bug)

12.13 Version 0.18

- Fix version numbering setup
- Fix #92 (can ignore blah blah lines in ~C section)
- Fix #209 (can now add curves with LASFile['mnemonic'] = [1, 2, 3])
- Fix #213 (LASFile.data is now a lazily generated property, with setter)
- Fix #218 (LASFile.append_curve was not adding data=[...] properly)
- Fix #216 (LASFile now raises KeyError for missing mnemonics)
- Fix #214 (first duplicate mnemonic when added was missing the :1)

12.14 Version 0.17

- Add Appveyor continuous integration testing
- Add example notebook for how to use python logging module
- Fix #160 (add methods to LASFile for inserting curves)
- Fix #155 (implement del keyword for header items)
- Fix #142 (implement slicing for SectionItems)
- Fix #135 (UWI numbers losing their leading zeros)
- Fix #153 (fix SectionItems pprint repr in Python 3)
- Fix #81 (accept header items with missing colon)

- Fix #71 (add Docker build for lasio to DockerHub)
- Fix #210 (allow upper/lowercase standardization of mnemonics on read)
- Document recent additions (nearly up to date) (in Sphinx docs)

12.15 Version 0.16

- Add read_policy and null_policy keywords - see documentation for details
- Fix bugs around files with missing ~V ~W ~P or ~C sections (#84 #85 #78)
- Fix #17 involving files with commas as a decimal mark
- Improve LASHeaderError traceback message
- Fix bug involving files with ~A but no data lines following
- Fix bug with blank line at start of file
- Fix bug involving missing or duplicate STRT, STOP and STEP mnemonics

12.16 Version 0.15.1

- Major performance improvements with both memory and speed
- Major improvement to read parser, now using iteration
- Add `LASFile.to_excel()` and `LASFile.to_csv()` export methods
- Improve `las2excelbulk.py` script
- Published new and updated Sphinx documentation
- Improved character encoding handling when `chardet` not installed
- `autodetect_encoding=True` by default
- Allow reading of multiple non-standard header sections (#167, #168)
- Add flexibility in reading corrupted headers (`ignore_header_errors=True`)
- Add ability to avoid reading in data (`ignore_data=True`)
- Remove excessive debugging messages
- Fix bug #164 where `FEET` was not recognised as `FT`
- Fix major globals() bug #141 affecting LASFile.add_curve
- Add command-line version script `$ lasio` to show version number.

Version 0.14 and 0.15 skipped due to broken PyPI upload.

12.17 Version 0.13

- Other minor bug fixes inc inability to rename mnemonics in written LAS file.

12.18 Version 0.11.2

- Fix bug with not correctly figuring out units for LASFile.write()
- Add `LASFile.add_curve(CurveItem)` method which automatically goes to the old method at `LASFile.add_curve_raw(mnemonic=, data=, ...)` if necessary, so it should be transparent to users

12.19 Version 0.11

- Reorganise code into modules
- various

12.20 Version 0.10

- Internal change to SectionItems for future LAS 3.0 support
- Added JSON encoder
- Added examples for using pandas DataFrame (.df attribute)
- LAS > Excel script refined (las2excel.py)

12.21 Version 0.9.1 (2015-11-11)

- pandas.DataFrame now as .df attribute, bugfix

12.22 Version 0.8 (2015-08-20)

- numerous bug fixes, API documentation added

12.23 Version 0.7 (2015-08-08)

- all tests passing on Python 2.6 through 3.4

12.24 Version 0.6 (2015-08-05)

- bugfixes and renamed from `las_reader` to `lasio`

12.25 Version 0.5 (2015-08-01)

- Improvements to writing LAS files

12.26 Version 0.4 (2015-07-26)

- Improved handling of character encodings, other internal improvements

12.27 Version 0.3 (2015-07-23)

- Added Python 3 support, now reads LAS 1.2 and 2.0

12.28 Version 0.2 (2015-07-08)

- Tidied code and published on PyPI
- genindex
- search

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