In-class exercise for tutorial 010

In this exercise we will practice making datasets. We will on the one hand simulating data, on the other hand not quite as we will be making some asumptions and simplifaction on the data generation process that will not make the data.

Nestor lives right under the ATX airport, along the routes of airliners from major companies (United, Delt, etc).

Because of that Nestor hears noise. The noise is generated by the airplanes landing and taking off. There is a lot of noise that is generated by these airplanes. One day Nestor decides to simulate the noise generated by the airplanes and reaching his years. Nestor is worried about his hearing loss.

The problem to simulate

Nestor is interested in calculating how much noise he is being exposed to. So he goes and looks up the timetable during the 3 hours window in the morning, when he is at home, and during the 7 hours window in the evening, when he is at hom, and before midnight when the airport shuts down and no more flights land or takeoff.

Nestor lives about 2 miles away from the airport. At that distance each jet generates about 75-80 dB (Decibels). We will say 75dB. In the morning there are about 60 airplanes that land/takeoff. Each airplane can be heard consistently for about 7 minutes (we will assume a flat top distribution of the dBs, no ramp up, no decay, a simple flat distribution).

In the 3 hours window of the morning, Airplanes depart and land every 3 minutes, so their noise overlap for about 4 minutes. The dB of an airplane is corrupted by noise due to the city and nature around around, the cars, trains, trucks (all add some noise, randomly) and the position of the moving cloud in the sky, the wind and humidity (all diminish the noise randomly). So the noise is never 75dB but it stays on average around 75 dB while being corrupted by noise.

In the 7 hours window of the evening, Airplanes depart and land about every 4 minutes, so their noise overlaps for about 3 minutes.

Nestor will assume a linear summation of the airplane noise in a single day. This is not the best way especially when dealing with dB, but this is a simple exercise and we can break some fundamental physics rules to make things easier for us. We will want to simulate the situation.

How many airplanes depart/land in the morning window of a single day? How many in the evening window?

In [1]:
```
# give descriptive names to the values given above

noysLevel = 75         # in dB
noysVar = 2            # a complete guess about variability in the noise level
sharedEnvNoys = 45     # there is environmental noise that is separate from the variatio
planeIntervalAM = 3    # how often the planes land
planeIntervalPM = 4
noysMinPerPlane = 7    # how long the noise from each plane lands
```

```
# length of morning and evening time blocks in minutes
mornMins = 3*60 # hr * min/hr = min
eveMins = 7*60

# total number of planes in the morning and evening
mornPlanes = mornMins/planeIntervalAM
evePlanes = eveMins/planeIntervalPM
print(mornPlanes, 'planes in the morning and ', evePlanes, ' planes in the evening.')
```

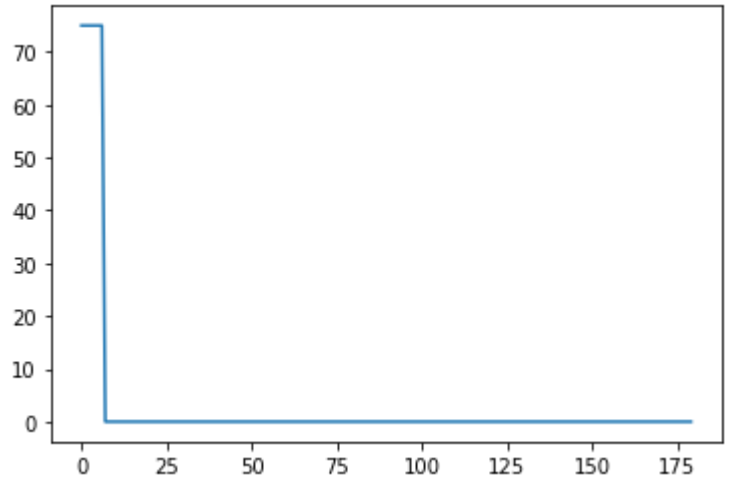
```
60.0 planes in the morning and  105.0  planes in the evening.
```

Show the noise priofle of one airplane in the morning (pure for the moment without other external noise)

In [2]:
```
#Importing the stuff I need
import numpy as np
import matplotlib.pyplot as plt
```

In [3]:
```
'''
Okay, now, in order to show a noise profile, we need a place to hold the data.
We also know from what we just calculated that we will ultimately be doing this
for 60 (!) planes.
So we can start by either:
- making a place for just one plane - a 1 plane by 180 min array - and go from there, o
- make room for all the plane data - a 60 plane by 180 min array - right now.

I'm going to start with a single plane and build up, because that's what the tutorial d
'''


plane1Noys = np.zeros([mornMins, 1])           # make a minutes x 1 numpy array
plane1Noys[0:noysMinPerPlane, :] = noysLevel   # make the first 7 minutes LOUD!
plt.plot(plane1Noys)                           # and plot
```

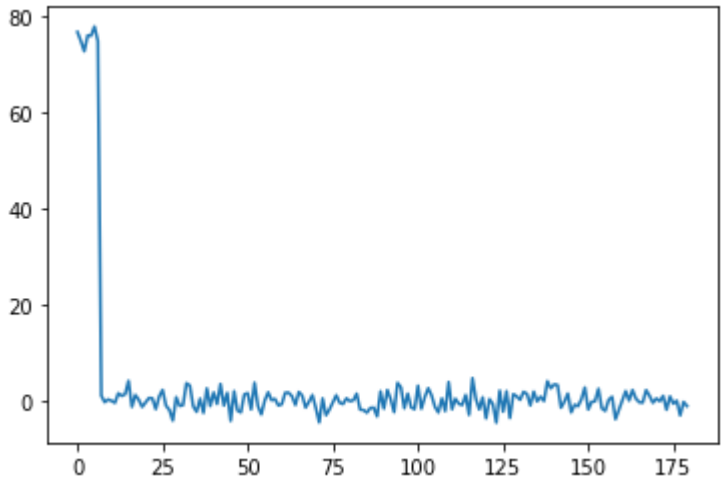
Out[3]:
```
[<matplotlib.lines.Line2D at 0x226ef1f8a30>]
```



Creating a plot the first plane's noise with additional environmental noise

In [4]:
```
envNoys = noysVar*np.random.randn(mornMins, 1)   # make random "environmental noise"
# envNoys must be the same shape as plane1Noys to add them together
# can make envNoys the same shape as plane1Noys by doing this:
```

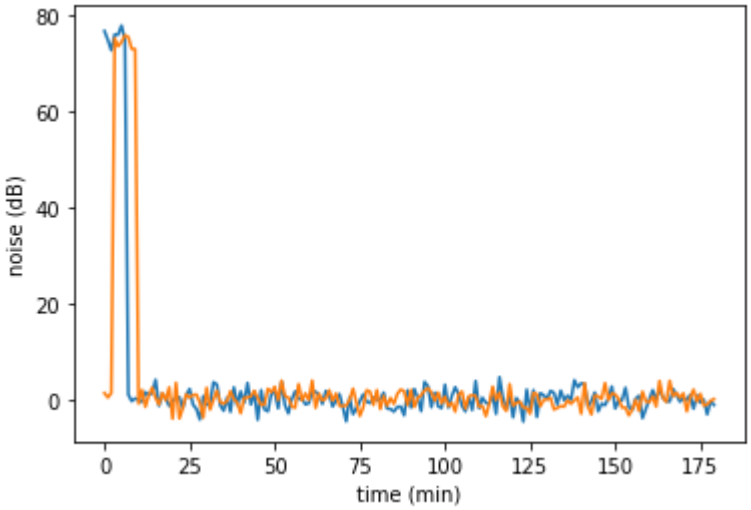
```
# envNoys = noysVar*np.random.randn(*plane1Noys.shape)
# must use the * to unpack the tuple and create a separate argument for each dimension
plane1Noys = plane1Noys + envNoys                # add it to the "pure" plane noise
plt.plot(plane1Noys);
```



Now add a second airplane, corrupted by noise but departing/landing at a different time. Make a plot of the two airplanes together.

In [5]:
```
'''
This is really 4 steps
(though some or all of them could be combined into shorter but harder-to-read code):
- figure out what time this plane's noise should start and stop
- make the second airplane noise profile
- add environmental noise to it
- combine it with the first plane's noise profile into a 180 minute by 2 plane array
'''
start = planeIntervalAM  # second plane noise should start 3 min in
stop = start + noysMinPerPlane # should stop 7 minutes later

plane2Noys = np.zeros([mornMins, 1])   # make numpy array
plane2Noys[start:stop, :] = noysLevel  # make some noise! hopefully at the right place

envNoys = noysVar*np.random.randn(mornMins, 1) # make the randomness of life
plane2Noys = plane2Noys + envNoys # add enviro noise

planeNoys = np.hstack((plane1Noys,  plane2Noys)) # make a new array by joining our plan

plt.plot(planeNoys); # and plot (use the terminal semicolon so you get ONLY the plot)
plt.xlabel('time (min)')
plt.ylabel('noise (dB)')
```

Out[5]:
```
Text(0, 0.5, 'noise (dB)')
```



Finally, simulate all the airplanes that you have estimated to land/depart in the morning. Plot them on the same figure.

In [6]:
```
'''
Okay. If we are going to figure out how to make 58 more planes, we have to ask ourselve
"When we went from making plane 1 to plane 2, what EXACTLY did we need to change?"
If we can figure out an easy way to change that (and only that), the making the rest of
planes should be straightforward. Boring AF, but straight forward.

So what changed? The only thing that changed was THE STARTING TIME OF THE PLANE NOISE.
That's it. That's all we need to change.

(You might say "Wait, the stopping time changed too!" True, but the stopping time is al
7 minutes after the start time, so as long as we bake that in, we shouldn't have to wor
about it.)

Let's compare the start and stop times for our first two planes from above
these are just the indexes at which we added "75"

    plane 1: 0,               noysMinPerPlane
    plane 2: planeIntervalAM, planeIntervalAM + noysMinPerPlane

plane 3 would just be another 3 minutes in, so adding it would look like:

    plane 1: 0,                                   noysMinPerPlane
    plane 2: planeIntervalAM,                     planeIntervalAM + noysMinPerPlane
    plane 3: planeIntervalAM + planeIntervalAM, planeIntervalAM + planeIntervalAM + noy

or

    plane 1: 0,                 noysMinPerPlane
    plane 2: planeIntervalAM,   planeIntervalAM + noysMinPerPlane
    plane 3: 2*planeIntervalAM, 2*planeIntervalAM + noysMinPerPlane

So in terms of the start times of the noise, all the planes would be:

    start = 0, planeIntervalAM, 2*planeIntervalAM, 3*planeIntervalAM, 4*planeIntervalAM
    stop = start + noysMinPerPlane (for every plane)

In fact, let's say we assigned each plane a "planeID", such that
plane 1 was planeID = 0, plane 2 was planeID = 1, etc.
```

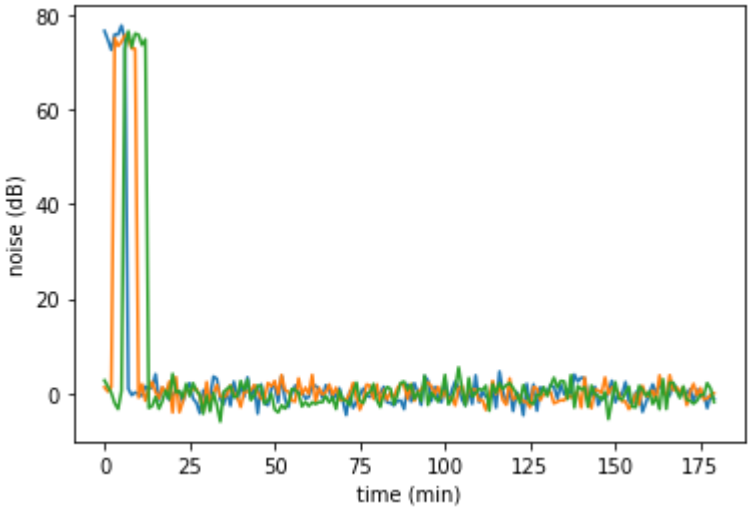
```
Then our starting times FOR EVERY PLANE would be:

    start = planeID*planeIntervalAM

And the stop times would, again, be just:

    stop = start + noysMinPerPlane

I told you the stop never had to change! The numerical value of "stop" will change, but
That's the power of variables!
'''
```

Out[6]:

```
'\nOkay. If we are going to figure out how to make 58 more planes, we have to ask oursel
ves\n"When we went from making plane 1 to plane 2, what EXACTLY did we need to chang
e?"\nIf we can figure out an easy way to change that (and only that), the making the res
t of the \nplanes should be straightforward. Boring AF, but straight forward.\n\nSo what
changed? The only thing that changed was THE STARTING TIME OF THE PLANE NOISE.\nThat\'s
it. That\'s all we need to change.\n\n(You might say "Wait, the stopping time changed to
o!" True, but the stopping time is always\n7 minutes after the start time, so as long as
we bake that in, we shouldn\'t have to worry\nabout it.)\n\nLet\'s compare the start and
stop times for our first two planes from above\nthese are just the indexes at which we a
dded "75"\n\n    plane 1: 0,                noysMinPerPlane\n    plane 2: planeIntervalA
M, planeIntervalAM + noysMinPerPlane\n\nplane 3 would just be another 3 minutes in, so a
dding it would look like:\n\n    plane 1: 0,                                    noysMinPerP
lane\n    plane 2: planeIntervalAM,                  planeIntervalAM + noysMinPerPlane
\n    plane 3: planeIntervalAM + planeIntervalAM, planeIntervalAM + planeIntervalAM + no
ysMinPerPlane\n\nor \n\n    plane 1: 0,                  noysMinPerPlane\n    plane 2: pl
aneIntervalAM,   planeIntervalAM + noysMinPerPlane\n    plane 3: 2*planeIntervalAM, 2*pl
aneIntervalAM + noysMinPerPlane\n\nSo in terms of the start times of the noise, all the
planes would be:\n\n    start = 0, planeIntervalAM, 2*planeIntervalAM, 3*planeIntervalA
M, 4*planeIntervalAM...\n    stop = start + noysMinPerPlane (for every plane)\n\nIn fac
t, let\'s say we assigned each plane a "planeID", such that \nplane 1 was planeID = 0, p
lane 2 was planeID = 1, etc. \n\nThen our starting times FOR EVERY PLANE would be:\n\n
start = planeID*planeIntervalAM\n\nAnd the stop times would, again, be just:\n\n    stop
= start + noysMinPerPlane\n\nI told you the stop never had to change! The numerical valu
e of "stop" will change, but not it\'s code. \nThat\'s the power of variables!\n'
```

In [7]:

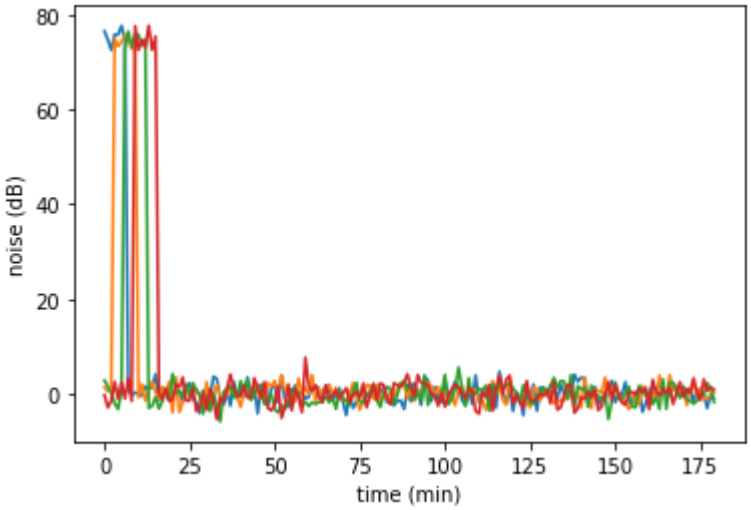
```
# Make the third plane

# figure out start and stop
planeIndex = 2  # the first plane was 0
start = planeIndex*planeIntervalAM  # noise should start 6 min in for 3rd plane
stop = start + noysMinPerPlane      # and always stops 7 minutes later

# make the noise profile
plane3Noys = np.zeros([mornMins, 1])            # make our array
plane3Noys[start:stop, :] = noysLevel           # add the plane noise
envNoys = noysVar*np.random.randn(mornMins, 1)  # random clouds, trees, unicorns, etc.
plane3Noys = plane3Noys + envNoys               # add the enviro noise

# append it to our "all planes" array
planeNoys = np.hstack((planeNoys,  plane3Noys)) # add new plane as column to big array

# and plot
plt.plot(planeNoys); # and plot (use the terminal semicolon so you get ONLY the plot)
plt.xlabel('time (min)');
plt.ylabel('noise (dB)');
```



Okay, awesome. So we sort of have a workflow. But now let us notice one other little thing... We keep storing each new planes noise profile in its own numpy array (plane2Noys, plane3Noys...) but then we just tack its values on to the big array, and then we don't need it anymore. In other words, all we need is a generic noise profile container; it doesn't have to be plane specific. If we do that, then **the only thing we'll need to change in our code to make new planes is `planeID` !** Let's see:

In [8]:

```
# Make the fourth plane using a genertic "nextPlaneNoys" array

# figure out start and stop
planeIndex = 3  # THIS IS THE ONLY THING WE SHOULD NEED TO CHANGE NOW
start = planeIndex*planeIntervalAM  # noise should start 6 min in for 3rd plane
stop = start + noysMinPerPlane      # and always stops 7 minutes later

# make the noise profile
nextPlaneNoys = np.zeros([mornMins, 1])         # make our array
nextPlaneNoys[start:stop, :] = noysLevel        # add the plane noise
envNoys = noysVar*np.random.randn(mornMins, 1)  # delicious randomness that makes life
nextPlaneNoys = nextPlaneNoys + envNoys         # add life's randomness

# append it to our "all planes" array
planeNoys = np.hstack((planeNoys,  nextPlaneNoys)) # add new plane as column to big arr

# and plot
plt.plot(planeNoys); # and plot (use the terminal semicolon so you get ONLY the plot)
plt.xlabel('time (min)');
plt.ylabel('noise (dB)');
```



Okay, that worked! So now we just need to copy and paste and just change planeID. Subsequent plane noises will all be stored in the same `nextPlaneNoys` array and then the values will be tacked onto our big planeNoys array.

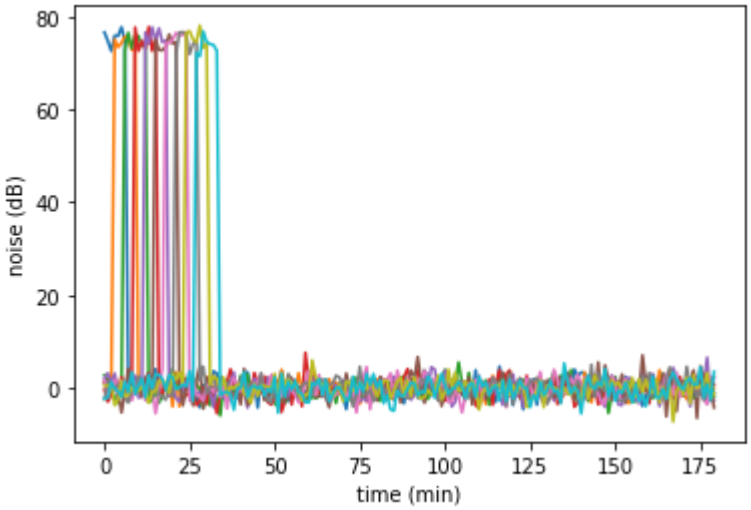
Let's make just 10 planes - that will make the point.

In [9]:

```
################# Next plane please! ####################
# figure out start and stop
planeIndex = 4  # THIS IS THE ONLY THING CHANGING NOW!
start = planeIndex*planeIntervalAM  # noise should start 6 min in for 3rd plane
stop = start + noysMinPerPlane      # and always stops 7 minutes later

# make the noise profile
nextPlaneNoys = np.zeros([mornMins, 1])  # make our array for this first time only!
nextPlaneNoys[start:stop, :] = noysLevel # add the plane noise
envNoys = noysVar*np.random.randn(mornMins, 1)
nextPlaneNoys = nextPlaneNoys + envNoys # add the enviro noise

# append it to our "all planes" array
planeNoys = np.hstack((planeNoys,  nextPlaneNoys)) # add new plane as column to big arr


################# Next plane please! ####################
# figure out start and stop
planeIndex = 5  # THIS IS THE ONLY THING CHANGING NOW!
start = planeIndex*planeIntervalAM  # noise should start 6 min in for 3rd plane
stop = start + noysMinPerPlane      # and always stops 7 minutes later

# make the noise profile
nextPlaneNoys = np.zeros([mornMins, 1])  # zero out the array
nextPlaneNoys[start:stop, :] = noysLevel # add the plane noise
envNoys = noysVar*np.random.randn(mornMins, 1)
nextPlaneNoys = nextPlaneNoys + envNoys # add the enviro noise

# append it to our "all planes" array
planeNoys = np.hstack((planeNoys,  nextPlaneNoys)) # add new plane as column to big arr


################# Next plane please! ####################
# figure out start and stop
planeIndex = 6  # THIS IS THE ONLY THING CHANGING NOW!
```

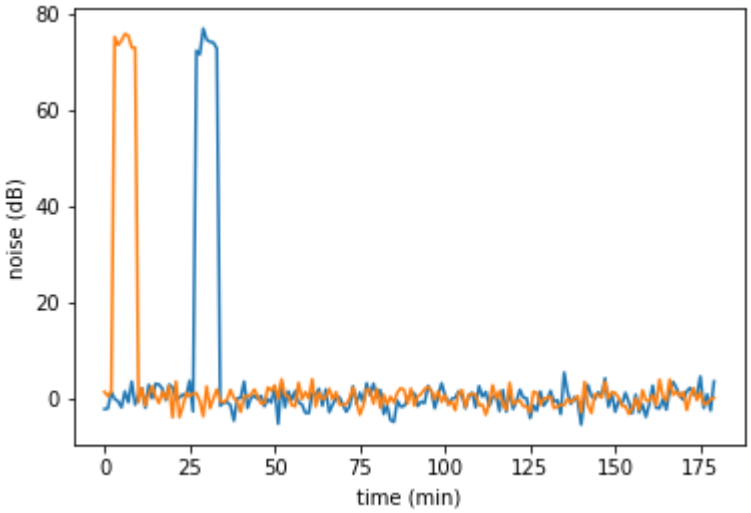
```
start = planeIndex*planeIntervalAM  # noise should start 6 min in for 3rd plane
stop = start + noysMinPerPlane      # and always stops 7 minutes later

# make the noise profile
nextPlaneNoys = np.zeros([mornMins, 1])  # zero out the array
nextPlaneNoys[start:stop, :] = noysLevel # add the plane noise
envNoys = noysVar*np.random.randn(mornMins, 1)
nextPlaneNoys = nextPlaneNoys + envNoys # add the enviro noise

# append it to our "all planes" array
planeNoys = np.hstack((planeNoys,  nextPlaneNoys)) # add new plane as column to big arr


################ Next plane please! ###################
# figure out start and stop
planeIndex = 7  # THIS IS THE ONLY THING CHANGING NOW!
start = planeIndex*planeIntervalAM  # noise should start 6 min in for 3rd plane
stop = start + noysMinPerPlane      # and always stops 7 minutes later

# make the noise profile
nextPlaneNoys = np.zeros([mornMins, 1])  # zero out the array
nextPlaneNoys[start:stop, :] = noysLevel # add the plane noise
envNoys = noysVar*np.random.randn(mornMins, 1)
nextPlaneNoys = nextPlaneNoys + envNoys # add the enviro noise

# append it to our "all planes" array
planeNoys = np.hstack((planeNoys,  nextPlaneNoys)) # add new plane as column to big arr


################ Next plane please! ###################
# figure out start and stop
planeIndex = 8  # THIS IS THE ONLY THING CHANGING NOW!
start = planeIndex*planeIntervalAM  # noise should start 6 min in for 3rd plane
stop = start + noysMinPerPlane      # and always stops 7 minutes later

# make the noise profile
nextPlaneNoys = np.zeros([mornMins, 1])  # zero out the array
nextPlaneNoys[start:stop, :] = noysLevel # add the plane noise
envNoys = noysVar*np.random.randn(mornMins, 1)
nextPlaneNoys = nextPlaneNoys + envNoys # add the enviro noise

# append it to our "all planes" array
planeNoys = np.hstack((planeNoys,  nextPlaneNoys)) # add new plane as column to big arr


################ Next plane please! ###################
# figure out start and stop
planeIndex = 9  # THIS IS THE ONLY THING CHANGING NOW!
start = planeIndex*planeIntervalAM  # noise should start 6 min in for 3rd plane
stop = start + noysMinPerPlane      # and always stops 7 minutes later

# make the noise profile
nextPlaneNoys = np.zeros([mornMins, 1])  # zero out the array
nextPlaneNoys[start:stop, :] = noysLevel # add the plane noise
envNoys = noysVar*np.random.randn(mornMins, 1)
nextPlaneNoys = nextPlaneNoys + envNoys # add the enviro noise

# append it to our "all planes" array
planeNoys = np.hstack((planeNoys,  nextPlaneNoys)) # add new plane as column to big arr
```

In [10]:
```
# and plot
plt.plot(planeNoys); # and plot (use the terminal semicolon so you get ONLY the plot)
plt.xlabel('time (min)');
plt.ylabel('noise (dB)');
# plt.xlim([0, 25])
```



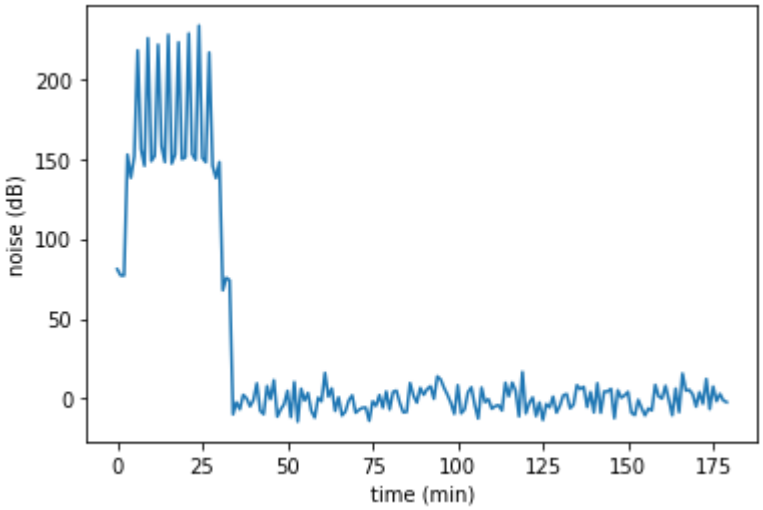
Peek at the second and last plane – they should look like shifted copies of each other.

In [11]:
```
plt.plot(planeNoys[:,-1]);
plt.plot(planeNoys[:,1]);
plt.xlabel('time (min)');
plt.ylabel('noise (dB)');
```



And now – finally! – let's see what the total amount of noise poor Nestor has to deal with during the first half hour of his morning.

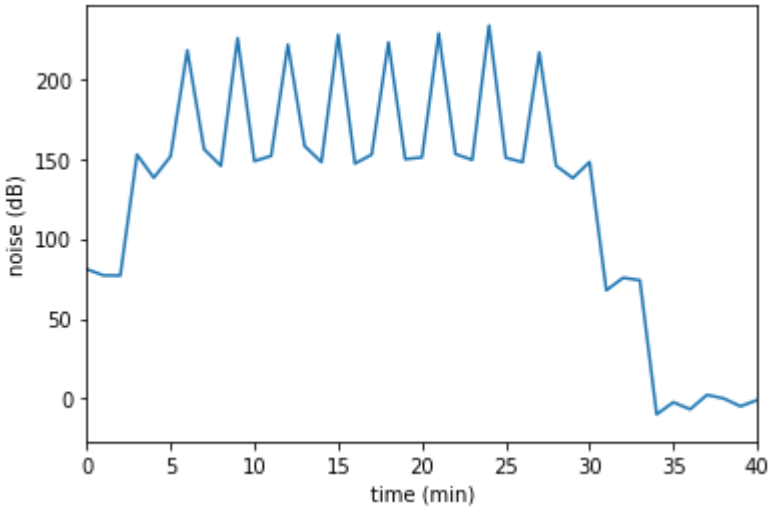
In [12]:
```
plt.plot(np.sum(planeNoys, 1)); # and plot (use the terminal semicolon so you get ONLY
plt.xlabel('time (min)');
plt.ylabel('noise (dB)');
# plt.xlim([0, 25])
```



Let's zoom in on the first 40 minutes of poor Nestor's morning.

In [13]:
```
plt.plot(np.sum(planeNoys, 1)); # and plot (use the terminal semicolon so you get ONLY
plt.xlabel('time (min)');
plt.ylabel('noise (dB)');
plt.xlim([0, 40])
```

Out[13]:
```
(0.0, 40.0)
```



My Part

So here's our mission: See if you can write some similar code in which you can generate 10 planes of noise data in a single 180x10 numpy array, **where only one number needs to change across planes**. Then compute the total noise over time and make sure you get something like the above.

If you have that handled and have spare time or brain cycles, see if you if you can do this **using only one numpy array** – a 180 min by 10 plane array – and no additional arrays to hold individual plane noise or environmental noise.

Brain challange: we have used different "environmental" noise for each plane over the *same* 180 minutes? Is this reasonable? Or might there be environmental noise that should be common to all of the planes' noise profiles?

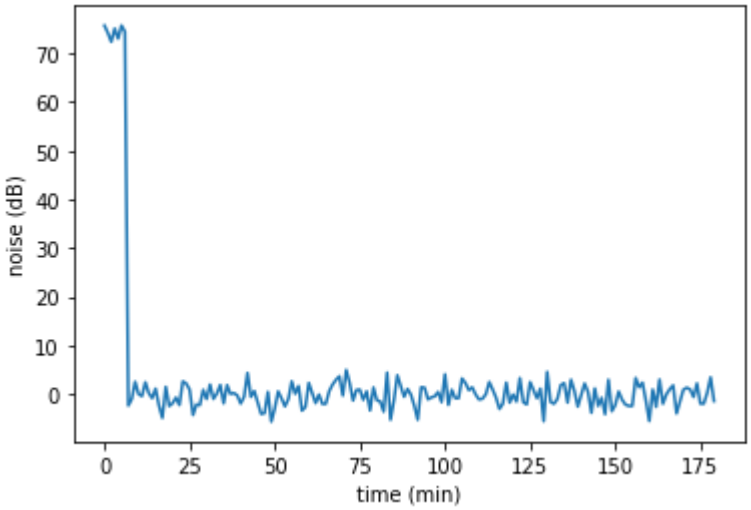
First Mission

So here's our mission: See if you can write some similar code in which you can generate 10 planes of noise data in a single 180x10 numpy array, **where only one number needs to change across planes**. Then compute the total noise over time and make sure you get something like the above.

In [14]:
```
planeNoys = np.zeros([mornMins, 1]) # creating a large array for the morning to insert
```

In [15]:
```
#figure out start and stop of the first plane
planeIndex = 0 # THIS IS THE ONLY THING WE SHOULD NEED TO CHANGE
start = planeIndex*planeIntervalAM
stop = start + noysMinPerPlane

#make the noise profile\nextPLaneNoys = np.zeros((mornMins, 1))
nextPlaneNoys = np.zeros((mornMins, 1)) # make reusable numpy array to hold the plane n
nextPlaneNoys[start:stop, :] = noysLevel # insert the uncorrupted plane noise for plane
envNoys = noysVar*np.random.randn(mornMins, 1) # create environmental noise array with
planeNoys = nextPlaneNoys + envNoys #inserting the first plane noise into the large arr

#plottiong to make sure it worked
plt.plot(planeNoys)
plt.xlabel('time (min)')
plt.ylabel('noise (dB)')
```

Out[15]:
```
Text(0, 0.5, 'noise (dB)')
```



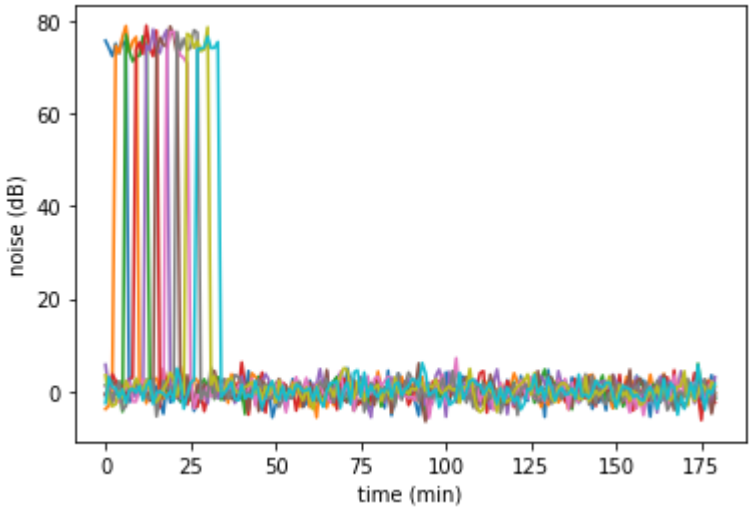
Inserting all the planes

In [16]:
```
############ NEXT PLANE ##############
#figure out start and stop of the first plane
planeIndex = 1 # THIS IS THE ONLY THING WE SHOULD NEED TO CHANGE
start = planeIndex*planeIntervalAM
stop = start + noysMinPerPlane
```

```
#make the noise profile\nextPLaneNoys = np.zeros((mornMins, 1))
nextPlaneNoys = np.zeros((mornMins, 1)) # make reusable numpy array to hold the plane n
nextPlaneNoys[start:stop, :] = noysLevel # insert the uncorrupted plane noise for plane
envNoys = noysVar*np.random.randn(mornMins, 1) # create environmental noise array with
nextPlaneNoys = nextPlaneNoys + envNoys

#append it tour "all planes" array
planeNoys = np.hstack((planeNoys, nextPlaneNoys)) #now I have a 180x2 array

########### NEXT PLANE ##############
#figure out start and stop of the first plane
planeIndex = 2 # THIS IS THE ONLY THING WE SHOULD NEED TO CHANGE
start = planeIndex*planeIntervalAM
stop = start + noysMinPerPlane

#make the noise profile\nextPLaneNoys = np.zeros((mornMins, 1))
nextPlaneNoys = np.zeros((mornMins, 1)) # make reusable numpy array to hold the plane n
nextPlaneNoys[start:stop, :] = noysLevel # insert the uncorrupted plane noise for plane
envNoys = noysVar*np.random.randn(mornMins, 1) # create environmental noise array with
nextPlaneNoys = nextPlaneNoys + envNoys

#append it tour "all planes" array
planeNoys = np.hstack((planeNoys, nextPlaneNoys))


#######NEXT PLANE#########
#figure out start and stop of the first plane
planeIndex = 3 # THIS IS THE ONLY THING WE SHOULD NEED TO CHANGE
start = planeIndex*planeIntervalAM
stop = start + noysMinPerPlane

#make the noise profile\nextPLaneNoys = np.zeros((mornMins, 1))
nextPlaneNoys = np.zeros((mornMins, 1))
nextPlaneNoys[start:stop, :] = noysLevel
envNoys = noysVar*np.random.randn(mornMins, 1)
nextPlaneNoys = nextPlaneNoys + envNoys

#append it to our "all planes" array
planeNoys = np.hstack((planeNoys, nextPlaneNoys))


#######NEXT PLANE########
#figure out start and stop of the first plane
planeIndex = 4 # THIS IS THE ONLY THING WE SHOULD NEED TO CHANGE
start = planeIndex*planeIntervalAM
stop = start + noysMinPerPlane

#make the noise profile\nextPLaneNoys = np.zeros((mornMins, 1))
nextPlaneNoys = np.zeros((mornMins, 1))
nextPlaneNoys[start:stop, :] = noysLevel
envNoys = noysVar*np.random.randn(mornMins, 1)
nextPlaneNoys = nextPlaneNoys + envNoys

#append it to our "all planes" array
planeNoys = np.hstack((planeNoys, nextPlaneNoys))


#######NEXT PLANE#######
#figure out start and stop of the first plane
planeIndex = 5 # THIS IS THE ONLY THING WE SHOULD NEED TO CHANGE
```

```
start = planeIndex*planeIntervalAM
stop = start + noysMinPerPlane

#make the noise profile\nextPLaneNoys = np.zeros((mornMins, 1))
nextPlaneNoys = np.zeros((mornMins, 1))
nextPlaneNoys[start:stop, :] = noysLevel
envNoys = noysVar*np.random.randn(mornMins, 1)
nextPlaneNoys = nextPlaneNoys + envNoys

#append it to our "all planes" array
planeNoys = np.hstack((planeNoys, nextPlaneNoys))

#######NEXT PLANE#######
#figure out start and stop of the first plane
planeIndex = 6 # THIS IS THE ONLY THING WE SHOULD NEED TO CHANGE
start = planeIndex*planeIntervalAM
stop = start + noysMinPerPlane

#make the noise profile\nextPLaneNoys = np.zeros((mornMins, 1))
nextPlaneNoys = np.zeros((mornMins, 1))
nextPlaneNoys[start:stop, :] = noysLevel
envNoys = noysVar*np.random.randn(mornMins, 1)
nextPlaneNoys = nextPlaneNoys + envNoys

#append it to our "all planes" array
planeNoys = np.hstack((planeNoys, nextPlaneNoys))

#######NEXT PLANE#######
#figure out start and stop of the first plane
planeIndex = 7 # THIS IS THE ONLY THING WE SHOULD NEED TO CHANGE
start = planeIndex*planeIntervalAM
stop = start + noysMinPerPlane

#make the noise profile\nextPLaneNoys = np.zeros((mornMins, 1))
nextPlaneNoys = np.zeros((mornMins, 1))
nextPlaneNoys[start:stop, :] = noysLevel
envNoys = noysVar*np.random.randn(mornMins, 1)
nextPlaneNoys = nextPlaneNoys + envNoys

#append it to our "all planes" array
planeNoys = np.hstack((planeNoys, nextPlaneNoys))


#######NEXT PLANE#######
#figure out start and stop of the first plane
planeIndex = 8 # THIS IS THE ONLY THING WE SHOULD NEED TO CHANGE
start = planeIndex*planeIntervalAM
stop = start + noysMinPerPlane

#make the noise profile\nextPLaneNoys = np.zeros((mornMins, 1))
nextPlaneNoys = np.zeros((mornMins, 1))
nextPlaneNoys[start:stop, :] = noysLevel
envNoys = noysVar*np.random.randn(mornMins, 1)
nextPlaneNoys = nextPlaneNoys + envNoys

#append it to our "all planes" array
planeNoys = np.hstack((planeNoys, nextPlaneNoys))

#######NEXT PLANE#######
#figure out start and stop of the first plane
```

```
planeIndex = 9 # THIS IS THE ONLY THING WE SHOULD NEED TO CHANGE
start = planeIndex*planeIntervalAM
stop = start + noysMinPerPlane

#make the noise profile\nextPLaneNoys = np.zeros((mornMins, 1))
nextPlaneNoys = np.zeros((mornMins, 1))
nextPlaneNoys[start:stop, :] = noysLevel
envNoys = noysVar*np.random.randn(mornMins, 1)
nextPlaneNoys = nextPlaneNoys + envNoys

#append it to our "all planes" array
planeNoys = np.hstack((planeNoys, nextPlaneNoys))
plt.plot(planeNoys);
plt.xlabel('time (min)');
plt.ylabel('noise (dB)');
```



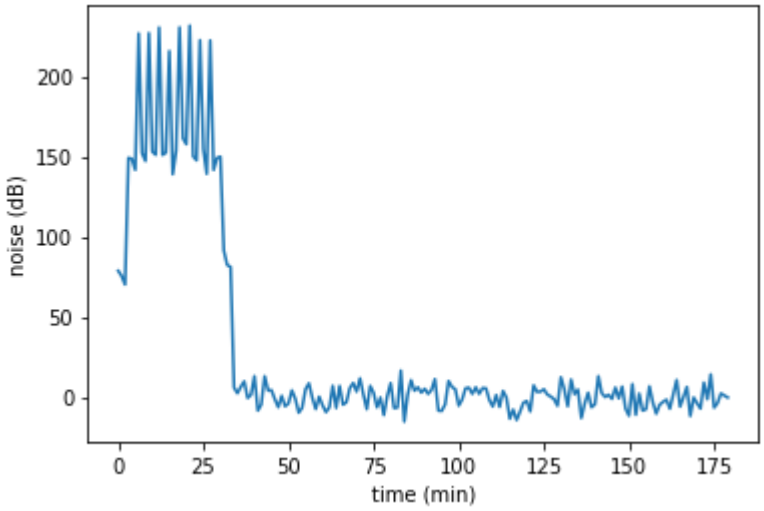
Zooming in on the first 40 minutes

In [17]:

```
#Total noise over time
plt.plot(np.sum(planeNoys, 1)); # and plot (use the terminal semicolon so you get ONLY
plt.xlabel('time (min)')
plt.ylabel('noise (dB)')
```

Out[17]:

```
Text(0, 0.5, 'noise (dB)')
```



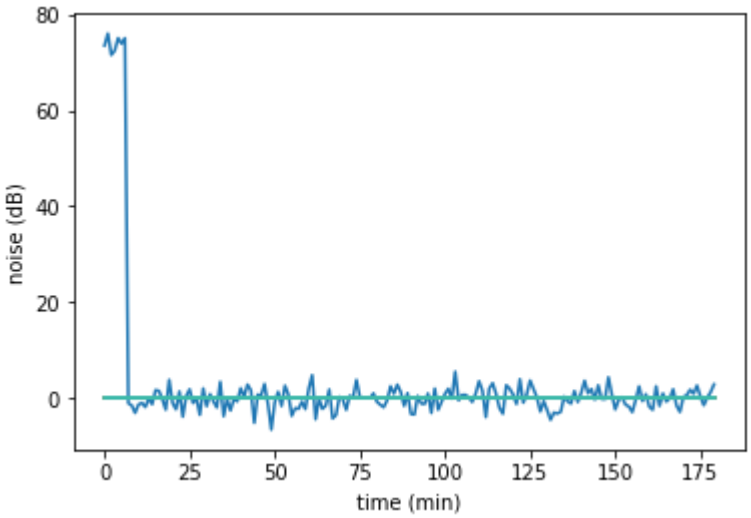
Second Mission

If you have that handled and have spare time or brain cycles, see if you if you can do this **using only one numpy array** – a 180 min by 10 plane array – and no additional arrays to hold individual plane noise or environmental noise.

In [18]:
```
# creating one large 180x10 numpy array
planeNoys = np.zeros([mornMins, 10])
```

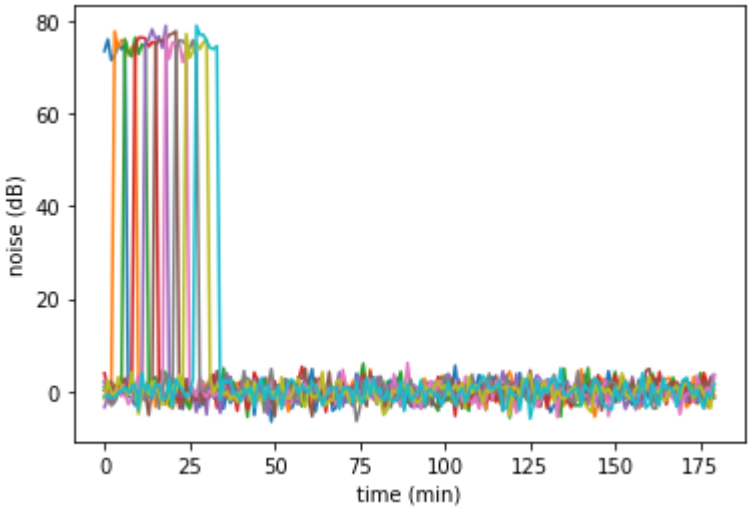
In [19]:
```
# first plane
planeIndex = 0
start = planeIndex*planeIntervalAM
stop = start + noysMinPerPlane
#make the noise profile
planeNoys[start:stop, planeIndex] = noysLevel  # inserting the plane noise for the firs
                                               #the first 7 minutes in the first column
planeNoys[:, planeIndex] = planeNoys[:, planeIndex] + noysVar*np.random.randn(*planeNoy
      # inserting enviro noise into the first column
```

In [20]:
```
#making sure it worked
plt.plot(planeNoys);
plt.xlabel('time (min)');
plt.ylabel('noise (dB)');
```

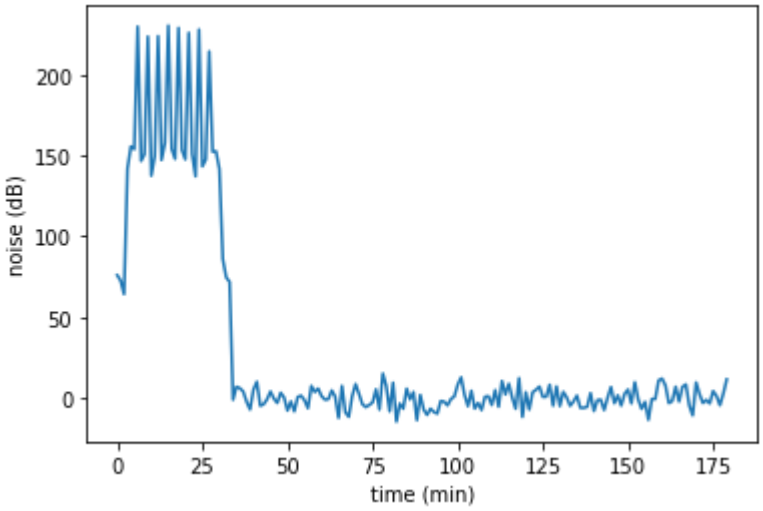


In [21]:
```
############## NEXT PLANE ########################
planeIndex = 1
start = planeIndex*planeIntervalAM
stop = start + noysMinPerPlane
planeNoys[start:stop, planeIndex] = noysLevel
planeNoys[:, planeIndex] = planeNoys[:, planeIndex] + noysVar*np.random.randn(*planeNoy

############## NEXT PLANE ########################
planeIndex = 2
start = planeIndex*planeIntervalAM
stop = start + noysMinPerPlane
planeNoys[start:stop, planeIndex] = noysLevel
planeNoys[:, planeIndex] = planeNoys[:, planeIndex] + noysVar*np.random.randn(*planeNoy
```

```
############ NEXT PLANE ######################
planeIndex = 3
start = planeIndex*planeIntervalAM
stop = start + noysMinPerPlane
planeNoys[start:stop, planeIndex] = noysLevel
planeNoys[:, planeIndex] = planeNoys[:, planeIndex] + noysVar*np.random.randn(*planeNoy

############ NEXT PLANE ######################
planeIndex = 4
start = planeIndex*planeIntervalAM
stop = start + noysMinPerPlane
planeNoys[start:stop, planeIndex] = noysLevel
planeNoys[:, planeIndex] = planeNoys[:, planeIndex] + noysVar*np.random.randn(*planeNoy

############ NEXT PLANE ######################
planeIndex = 5
start = planeIndex*planeIntervalAM
stop = start + noysMinPerPlane
planeNoys[start:stop, planeIndex] = noysLevel
planeNoys[:, planeIndex] = planeNoys[:, planeIndex] + noysVar*np.random.randn(*planeNoy

############ NEXT PLANE ######################
planeIndex = 6
start = planeIndex*planeIntervalAM
stop = start + noysMinPerPlane
planeNoys[start:stop, planeIndex] = noysLevel
planeNoys[:, planeIndex] = planeNoys[:, planeIndex] + noysVar*np.random.randn(*planeNoy

############ NEXT PLANE ######################
planeIndex = 7
start = planeIndex*planeIntervalAM
stop = start + noysMinPerPlane
planeNoys[start:stop, planeIndex] = noysLevel
planeNoys[:, planeIndex] = planeNoys[:, planeIndex] + noysVar*np.random.randn(*planeNoy

############ NEXT PLANE ######################
planeIndex = 8
start = planeIndex*planeIntervalAM
stop = start + noysMinPerPlane
planeNoys[start:stop, planeIndex] = noysLevel
planeNoys[:, planeIndex] = planeNoys[:, planeIndex] + noysVar*np.random.randn(*planeNoy

############ NEXT PLANE ######################
planeIndex = 9
start = planeIndex*planeIntervalAM
stop = start + noysMinPerPlane
planeNoys[start:stop, planeIndex] = noysLevel
planeNoys[:, planeIndex] = planeNoys[:, planeIndex] + noysVar*np.random.randn(*planeNoy

#Making sure it worked
plt.plot(planeNoys);
plt.xlabel('time (min)');
plt.ylabel('noise (dB)');
```



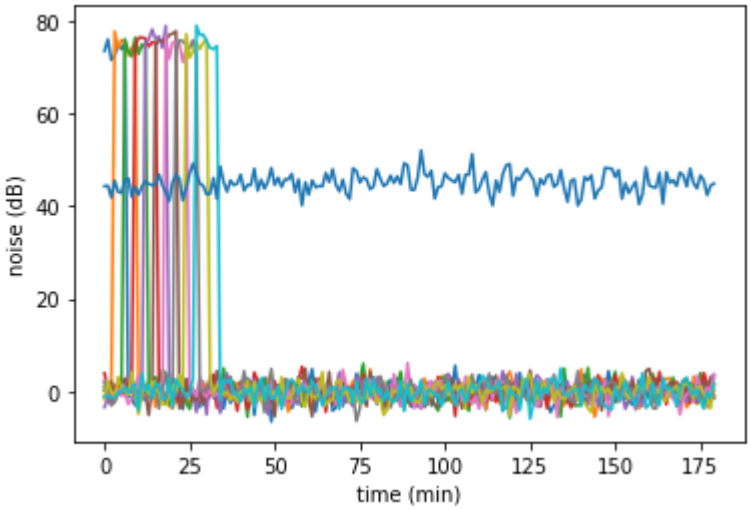
In [22]:
```
# total amount of noise in the morning
plt.plot(np.sum(planeNoys,1));
plt.xlabel('time (min)');
plt.ylabel('noise (dB)');
```



Third Mission

Brain challange: we have used different "environmental" noise for each plane over the *same* 180 minutes? Is this reasonable? Or might there be environmental noise that should be common to all of the planes' noise profiles?

In [23]:
```
# Creating a 180x1 array to contain the shared environmental noise
envNoys = np.zeros([mornMins, 1])
envNoys = sharedEnvNoys + noysVar*np.random.randn(*envNoys.shape) # inserting the share
                                                                  #with variability for
#adding the shared environmental noise as another column to the array holding the plane
planeNoys = np.hstack((planeNoys, envNoys))
plt.plot(planeNoys);
plt.xlabel('time (min)');
plt.ylabel('noise (dB)');
```



In [24]:

```
# Summing the noise from each plane and the shared environmental noise
plt.plot(np.sum(planeNoys, 1))
plt.xlabel('time (min)');
plt.ylabel('noise (dB)');
```