MVP for EDA project

This is a Minimum Viable Project for the EDA course. In this project, our customer is WTWY international, who want to support inclusion of women in technology fields as well as build awareness and contacts for the organisation. WTWY has a summar gala in NYC and would like to get more people to attend it to support the above goals, ideally people who will attend and contribute

WTWY has decided to place street teams at subway stations to collect signatures + email addresses in order to send free tickets, and would like to utilize our teams data analytics expertise in order to make the next annual gala a resounding success

Tips:

1. I might have put a bit too much in this notebook. To make it easier to navigate, I added a TOC
2. Use TOC to jump around, use the `<Home>` key to go back to TOC

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Goals

The goals for this MVP are as follows:

1. Gather and sort through statistics for subway station data and pick up to 5 stations with the highest foot traffic
2. Analyse the trend for these stations, going up, going down? busiest times during the day, busiest time during the year
3. Recommend the stations that will be the best places for street teams as well as the best times

Stretch target

1. WTWY would like to widen the reach of their organisation as well as get more people to contribute. A possible second source of data could be average net worth/salaries in a neighborhood, since a high average net worth/income indicates more disposable income and thus more likeliness to donate

Preliminary Analysis:

Importing the data

For this project, data is collected from MTA turnstile data at http://web.mta.info/developers/turnstile.html A convenience script (get_mta.py) is used to collect every weeks data for the year 2021, and load that into sqlite3 database mta_data.db

In [1]:
```
import pandas as pd
import sqlite3

con = sqlite3.connect("mta_data.db")
mta_data = pd.read_sql_query("SELECT * from mta_data", con)
```

In [2]:
```
mta_data.head()
```

Out[2]:

	C/A	UNIT	SCP	STATION	LINENAME	DIVISION	DATE	TIME	DESC	ENTRIES	E
0	A002	R051	02-00-00	59 ST	NQR456W	BMT	07/31/2021	00:00:00	REGULAR	7611181	260
1	A002	R051	02-00-00	59 ST	NQR456W	BMT	07/31/2021	04:00:00	REGULAR	7611192	260
2	A002	R051	02-00-00	59 ST	NQR456W	BMT	07/31/2021	08:00:00	REGULAR	7611197	260
3	A002	R051	02-00-00	59 ST	NQR456W	BMT	07/31/2021	12:00:00	REGULAR	7611235	260
4	A002	R051	02-00-00	59 ST	NQR456W	BMT	07/31/2021	16:00:00	REGULAR	7611357	260

In [3]:
```
mta_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 6697551 entries, 0 to 6697550
Data columns (total 11 columns):
 #   Column    Dtype 
---  ------    ----- 
 0   C/A       object
 1   UNIT      object
 2   SCP       object
 3   STATION   object
 4   LINENAME  object
 5   DIVISION  object
```

```
 6   DATE      object
 7   TIME      object
 8   DESC      object
 9   ENTRIES   int64
 10  EXITS     int64
dtypes: int64(2), object(9)
memory usage: 562.1+ MB
```

In [4]:
```
mta_data.describe()
```

Out[4]:

	ENTRIES	EXITS
count	6.697551e+06	6.697551e+06
mean	4.201677e+07	3.372964e+07
std	2.187455e+08	1.936177e+08
min	0.000000e+00	0.000000e+00
25%	2.204835e+05	9.477600e+04
50%	1.462864e+06	8.780630e+05
75%	6.135574e+06	4.034225e+06
max	2.147432e+09	2.123073e+09

In [5]:
```
mta_data.columns
```

Out[5]:
```
Index(['C/A', 'UNIT', 'SCP', 'STATION', 'LINENAME', 'DIVISION', 'DATE', 'TIME',
       'DESC', 'ENTRIES', 'EXITS'],
      dtype='object')
```

In [6]:
```
mta_data.isna().sum()
```

Out[6]:
```
C/A         0
UNIT        0
SCP         0
STATION     0
LINENAME    0
DIVISION    0
DATE        0
TIME        0
DESC        0
ENTRIES     0
EXITS       0
dtype: int64
```

In [7]:
```
mta_data.shape
```

Out[7]:
```
(6697551, 11)
```

Observation:

1. Date and time are string, and will have to be converted.
2. Entries and exits were imported as int correctly, and are the only numerical data
3. No NaN values for entries or exits. Number of observations is 6.69 M
4. There is a very large range for both entries and exits. [0, 2.147 *10^9] for entries. *Also relevant are the quartiles. The numbers are pretty similar, so lets just look at entries. median is 1.4* 10^6,

mean is 4.2 * 10^7 , which are both less than half of the range, indicating right skewness. So, majority of the numbers for entries are large, and there may be few small values.

From the first 5 rows above, the counters seem to be accumulating, and from above conclusion there is a chance that some counters have either reset or rolled over to start from minimum. Best case would be if the counters have reset at the beginning of our observations

Re-labelling

Change the column indices to lower case to make it easy to work with

In [8]:
```
mta_data.rename(columns=lambda x:x.strip().lower().replace('/','_'), inplace=Tru
mta_data.columns
```

Out[8]:
```
Index(['c_a', 'unit', 'scp', 'station', 'linename', 'division', 'date', 'time',
       'desc', 'entries', 'exits'],
      dtype='object')
```

In [9]:
```
mta_data.head()
```

Out[9]:

	c_a	unit	scp	station	linename	division	date	time	desc	entries	exits
0	A002	R051	02-00-00	59 ST	NQR456W	BMT	07/31/2021	00:00:00	REGULAR	7611181	2603110
1	A002	R051	02-00-00	59 ST	NQR456W	BMT	07/31/2021	04:00:00	REGULAR	7611192	2603113
2	A002	R051	02-00-00	59 ST	NQR456W	BMT	07/31/2021	08:00:00	REGULAR	7611197	2603126
3	A002	R051	02-00-00	59 ST	NQR456W	BMT	07/31/2021	12:00:00	REGULAR	7611235	2603178
4	A002	R051	02-00-00	59 ST	NQR456W	BMT	07/31/2021	16:00:00	REGULAR	7611357	2603211

Fix incorrect data types

Dates and times are string, need to be converted to proper pandas datetime stamps. Here we drop the time column, since the timestamp column is more useful.

In [10]:
```
mta_data['datetime'] = pd.to_datetime(mta_data['date'] + ' ' + mta_data['time'])
mta_data['date'] = pd.to_datetime(mta_data['date'])
mta_data.drop('time', axis=1, inplace=True)
```

Placeholder - Point of no return

From this point on, its unsafe to go back up, since we changed a column's ('date') data type, and dropped an
unnecessary column ('time')

In [11]:
```
mta_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 6697551 entries, 0 to 6697550
Data columns (total 11 columns):
 #   Column    Dtype
---  ------    -----
 0   c_a       object
 1   unit      object
 2   scp       object
 3   station   object
 4   linename  object
 5   division  object
 6   date      datetime64[ns]
 7   desc      object
 8   entries   int64
 9   exits     int64
 10  datetime  datetime64[ns]
dtypes: datetime64[ns](2), int64(2), object(7)
memory usage: 562.1+ MB
```

Sidenote 1:

What is not clear from the data is the relationship between station, c_a, unit and scp. station is obviously unique per NYC subway station. From the discussion in https://groups.google.com/g/mtadeveloperresources/c/z8l3ZU9cY6Y/m/OFlHGkFAimQJ and https://data.ny.gov/Transportation/Turnstile-Usage-Data-2020/py8k-a8wg, scp could be one or more turnstiles. So what are unit and c_a? Lets investigate by grouping by stations

In [14]:
```
temp = mta_data.groupby(['station'])[['unit', 'c_a', 'scp']].nunique()
temp.max()
```

Out[14]:
```
unit     6
c_a     13
scp     80
dtype: int64
```

Here we see that there seems to be a rough hierarchy among unit , c_a and scp (unit < c_a < scp) So, one station can have multiple units, each of which may have multiple control areas, and each of those may have multiple turnstiles This may not be useful in further analysis, but at least it hints at an order to the data It may also be theorized that a station with the largest no. of scp's should be one of the largest stations, and maybe subject to the most foot traffic

In [15]:
```
temp.sort_values('scp',ascending=False)[:3]
```

Out[15]:

station	unit	c_a	scp
FULTON ST	3	12	80
34 ST-PENN STA	4	13	63
GRD CNTRL-42 ST	4	8	53

In [16]:
```
temp = None
# Dont need this anymore, so release memory when convenient
```

Unique turnstile id

For the rest of the analysis from here on, we can consider a combination of unit, c_a and scp to be one unique turnstile. So, for a station like 'WALL ST', to get the total number of people exiting, we would need to add up the people exiting at each unique turnstile that belongs to that station

In [17]:
```
mta_data['turnstile_id'] = mta_data['unit'] + '_' + mta_data['c_a'] + '_' + mta_
```

In [18]:
```
mta_data.head()
```

Out[18]:

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	datetime	
0	A002	R051	02-00-00	59 ST	NQR456W	BMT	2021-07-31	REGULAR	7611181	2603110	2021-07-31 00:00:00	R05
1	A002	R051	02-00-00	59 ST	NQR456W	BMT	2021-07-31	REGULAR	7611192	2603113	2021-07-31 04:00:00	R05
2	A002	R051	02-00-00	59 ST	NQR456W	BMT	2021-07-31	REGULAR	7611197	2603126	2021-07-31 08:00:00	R05
3	A002	R051	02-00-00	59 ST	NQR456W	BMT	2021-07-31	REGULAR	7611235	2603178	2021-07-31 12:00:00	R05
4	A002	R051	02-00-00	59 ST	NQR456W	BMT	2021-07-31	REGULAR	7611357	2603211	2021-07-31 16:00:00	R05

Experiment 1:

Lets explore data just for one station - the one that showed up on top, just after import - 59 ST. We will attempt to find the number of people exiting the station for all of 2021.

Q: Why such a large range of dates for 2021 and station 59 ST ?

A: This is an experiment, just to check data ordering and consistency. Usually problems in data show up with large ranges

Q: Why not consider entry?

A: WTWY's volunteers wont be purchasing tickets, so they wont be within the turnstile, besides, for people entering the turnstile, they're probably in a hurry to catch their train

Q: Why not consider total people within the station i.e. entry - exit

A: The volunteers would need to purchase a ticket to be within the station. Usually theres rules for such stations probiting any solicitation. It'll be easier to keep a count of the exits, since people coming out of trains are usually more likely to have a few minutes to spend, so our volunteers can talk to them

In [19]:
```
temp = mta_data[(mta_data.station == '59 ST')].copy()
```

To find the total number of people exiting 59 ST station, we will have to group by turnstile, using our unique turnstile id. We create a column called delta, which has the difference between current entry and previous

In [20]:
```
temp.sort_values(['turnstile_id', 'datetime'], inplace=True)
temp.head()
```

Out[20]:

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	datet
6653205	R244A	R050	01-00-00	59 ST	456NQRW	IRT	2020-12-26	REGULAR	4926503	19829155	2020 03:0
6653206	R244A	R050	01-00-00	59 ST	456NQRW	IRT	2020-12-26	REGULAR	4926503	19829165	2020 07:0
6653207	R244A	R050	01-00-00	59 ST	456NQRW	IRT	2020-12-26	REGULAR	4926506	19829186	2020 11:0
6653208	R244A	R050	01-00-00	59 ST	456NQRW	IRT	2020-12-26	REGULAR	4926513	19829220	2020 15:0
6653209	R244A	R050	01-00-00	59 ST	456NQRW	IRT	2020-12-26	REGULAR	4926531	19829255	2020 19:0

In [21]:
```
temp.shape
```

Out[21]:
```
(75320, 12)
```

Now, lets check for duplicates.
First what would be a duplicate?
For station 59 ST, we would define a duplicate as having the
same turnstile id, and the same exact datetime

In [22]:
```
num_dups = temp[temp.duplicated(subset=['station', 'turnstile_id', 'datetime'])]
print("There are %d duplicates" % num_dups)
```

```
There are 0 duplicates
```

There are zero duplicates for 59 ST, so we can proceed with further analysis

In [23]:
```
temp['delta'] = temp.groupby('turnstile_id').exits.transform(lambda x: x.diff())
temp.head()
```

Out[23]:

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	datet
6653205	R244A	R050	01-00-00	59 ST	456NQRW	IRT	2020-12-26	REGULAR	4926503	19829155	2020 03:0
6653206	R244A	R050	01-00-00	59 ST	456NQRW	IRT	2020-12-26	REGULAR	4926503	19829165	2020 07:0

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	datet
6653207	R244A	R050	01-00-00	59 ST	456NQRW	IRT	2020-12-26	REGULAR	4926506	19829186	2020 11:0
6653208	R244A	R050	01-00-00	59 ST	456NQRW	IRT	2020-12-26	REGULAR	4926513	19829220	2020 15:0
6653209	R244A	R050	01-00-00	59 ST	456NQRW	IRT	2020-12-26	REGULAR	4926531	19829255	2020 19:0

In [24]:
```
temp.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 75320 entries, 6653205 to 24117
Data columns (total 13 columns):
 #   Column        Non-Null Count  Dtype         
---  ------        --------------  -----         
 0   c_a           75320 non-null  object        
 1   unit          75320 non-null  object        
 2   scp           75320 non-null  object        
 3   station       75320 non-null  object        
 4   linename      75320 non-null  object        
 5   division      75320 non-null  object        
 6   date          75320 non-null  datetime64[ns]
 7   desc          75320 non-null  object        
 8   entries       75320 non-null  int64         
 9   exits         75320 non-null  int64         
 10  datetime      75320 non-null  datetime64[ns]
 11  turnstile_id  75320 non-null  object        
 12  delta         75264 non-null  float64       
dtypes: datetime64[ns](2), float64(1), int64(2), object(8)
memory usage: 8.0+ MB
```

In [25]:
```
temp['delta'].describe()
```

Out[25]:
```
count    7.526400e+04
mean    -5.890545e+01
std      3.235048e+04
min     -8.869850e+06
25%      8.000000e+00
50%      3.200000e+01
75%      9.000000e+01
max      1.011000e+03
Name: delta, dtype: float64
```

Oops! Theres a problem, minimum is -8.86 * 10^6. Thats a very large negative, implying that the previous entry was an extremely large number. Did we just see a rollover? Lets check the first 5 such rows

In [26]:
```
temp.sort_values('delta')[:5]
```

Out[26]:

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	d
3977908	A002	R051	02-03-02	59 ST	NQR456W	BMT	2021-03-22	REGULAR	22	8	2 1

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	d
3095647	R244	R050	00-00-03	59 ST	456NQRW	IRT	2021-04-25	REGULAR	11	3	2 0
6232432	R245	R051	00-00-00	59 ST	456NQRW	IRT	2021-01-15	REGULAR	47	21	2 1
793992	R245	R051	00-03-02	59 ST	456NQRW	IRT	2021-07-14	REGULAR	1040923917	734763129	2 1
375104	R245	R051	00-03-02	59 ST	456NQRW	IRT	2021-07-29	REGULAR	1040926161	734747422	2 1

The first 3 rows seem to indicate a rollover, given the small number in exits columns. The last 3 merit further investigation. They seem to be for the same turnstile - c_a: R245A, unit R051, scp 01-00-02. First, lets check the first and second rows for a rollover

In [27]:
```
temp[
    (temp.turnstile_id == 'R051_A002_02-03-02')
    & (temp.date == '2021-03-22')
]
```

Out[27]:

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	datetim
3977904	A002	R051	02-03-02	59 ST	NQR456W	BMT	2021-03-22	REGULAR	6641438	8869481	2021-0 2 00:00:0
3977905	A002	R051	02-03-02	59 ST	NQR456W	BMT	2021-03-22	REGULAR	6641440	8869486	2021-0 2 04:00:0
3977906	A002	R051	02-03-02	59 ST	NQR456W	BMT	2021-03-22	REGULAR	6641446	8869630	2021-0 2 08:00:0
3977907	A002	R051	02-03-02	59 ST	NQR456W	BMT	2021-03-22	REGULAR	6641481	8869858	2021-0 2 12:00:0
3977908	A002	R051	02-03-02	59 ST	NQR456W	BMT	2021-03-22	REGULAR	22	8	2021-0 2 16:00:0
3977909	A002	R051	02-03-02	59 ST	NQR456W	BMT	2021-03-22	REGULAR	238	88	2021-0 2 20:00:0

In [28]:
```
temp[
    (temp.turnstile_id == 'R051_R245_00-00-00')
    & (temp.date == '2021-01-15')
]
```

Out[28]:

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	datetime

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	datetime
6232429	R245	R051	00-00-00	59 ST	456NQRW	IRT	2021-01-15	REGULAR	261134	76804	2021-01-15 03:00:00
6232430	R245	R051	00-00-00	59 ST	456NQRW	IRT	2021-01-15	REGULAR	261134	76811	2021-01-15 07:00:00
6232431	R245	R051	00-00-00	59 ST	456NQRW	IRT	2021-01-15	REGULAR	261148	76840	2021-01-15 11:00:00
6232432	R245	R051	00-00-00	59 ST	456NQRW	IRT	2021-01-15	REGULAR	47	21	2021-01-15 15:00:00
6232433	R245	R051	00-00-00	59 ST	456NQRW	IRT	2021-01-15	REGULAR	260	64	2021-01-15 19:00:00
6232434	R245	R051	00-00-00	59 ST	456NQRW	IRT	2021-01-15	REGULAR	366	79	2021-01-15 23:00:00

Yup!, Its a **rollover**, but strange enough, there doesnt seem to be a common number.
This indicates that each turnstile may have a different counter limit, so we can't just rely on a certain large number to indicate that a rollover is about to happen...

Ok, what about the other observations for turnstile R051_R245A_01-00-02 ?
Lets take a look...

In [29]:
```
temp[
    (temp.turnstile_id == 'R051_R245_00-03-02')
    & (temp.datetime >= '2021-07-13 04:00:00')
    & (temp.datetime <= '2021-07-14 19:00:00')
].sort_values('datetime')
```

Out[29]:

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	da
793984	R245	R051	00-03-02	59 ST	456NQRW	IRT	2021-07-13	REGULAR	1040923720	734764902	20 04
793985	R245	R051	00-03-02	59 ST	456NQRW	IRT	2021-07-13	REGULAR	1040923731	734764732	20 08
793986	R245	R051	00-03-02	59 ST	456NQRW	IRT	2021-07-13	REGULAR	1040923759	734764336	20 12
793987	R245	R051	00-03-02	59 ST	456NQRW	IRT	2021-07-13	REGULAR	1040923801	734764090	20 16
793988	R245	R051	00-03-02	59 ST	456NQRW	IRT	2021-07-13	REGULAR	1040923878	734763832	20 20
793989	R245	R051	00-03-02	59 ST	456NQRW	IRT	2021-07-14	REGULAR	1040923893	734763742	20 00

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	da
793990	R245	R051	00-03-02	59 ST	456NQRW	IRT	2021-07-14	REGULAR	1040923895	734763731	20 04
793991	R245	R051	00-03-02	59 ST	456NQRW	IRT	2021-07-14	REGULAR	1040923904	734763570	20 08
793992	R245	R051	00-03-02	59 ST	456NQRW	IRT	2021-07-14	REGULAR	1040923917	734763129	20 12
793993	R245	R051	00-03-02	59 ST	456NQRW	IRT	2021-07-14	REGULAR	1040923958	734762863	20 16

Huh??

This counter is actually counting *backwards*?

exit on date 2021-07-13, time 04:00:00 is 734764902, and at 8am, thats 734764732 , which is less that 734764902...

But the entries are increasing?

In [30]:
```
def_mask = (temp.delta < 0) & (temp.exits > 30)
num_def = temp[def_mask]['turnstile_id'].nunique()
print("Number of defective turnstiles: %d" % num_def)
bad_turnstile = temp[(temp.delta < 0) & (temp.exits > 30)]['turnstile_id'].value
print("Defective turnstile : %s" % bad_turnstile)
```

```
Number of defective turnstiles: 1
Defective turnstile : R051_R245_00-03-02
```

In [31]:
```
print(temp[(temp.turnstile_id == bad_turnstile) & (temp.delta < 0)]['datetime'].
print(temp[(temp.turnstile_id == bad_turnstile) & (temp.delta < 0)]['datetime'].
```

```
2021-08-06 20:00:00
2020-12-26 07:00:00
```

This seems to be a problem with just one turnstile on station 59 ST. And it seems to have been counting in reverse for the whole of 2021! Someone should probably inform MTA...

Meanwhile, for our analysis, we have concluded that it is best to discard negative deltas since they are either:

1. A rollover event, in which case, the previous entry is invalid for a delta
2. A defective counter, in which case, we cannot really trust any counts.

Any other problems? How about extremely large values?

In [32]:
```
num_huge_delta = temp[temp.delta > 14400].shape[0]
print("There are %d rows with delta values that are too large" % num_huge_delta)
```

```
There are 0 rows with delta values that are too large
```

Experiment 1 - Conclusion:

1. To find the total number of people exiting the station, we successfully calculate a delta value as the
   difference between current exit counter and previous
2. We did find negative values, which were for 2 reasons:

   a. Defective counter
   b. Rollover

   In both cases, our recommendation is to discard observations with negative delta

In [33]:
```
temp = None
# Release memory, experiment concluded
```

Solution:

Lets find the top stations, just for past 90 days. The following steps need to be completed:

1. We will first check for duplicates
2. Before calculating the difference of exit entries, we will need to sort by turnstile id and date, so we are
   taking delta from correct entries.
3. Calculate difference in exit numbers while grouping by station and turnstile, to avoid taking difference between different stations.
4. We will need to discard negative deltas, and/or any extreme values, and then add up exit delta's per station
5. Aggregate exit delta per station and find the top 5 highest traffic stations. Scatter/lineplot these

1. Check for duplicates

In [127…
```
from pandas import Timedelta as td
day_end = mta_data.datetime.max()
day_start = mta_data.datetime.max() - td(90, unit='days')
print("This duration starts at {}, and ends at {}".format(day_start, day_end))
```

```
This duration starts at 2021-05-08 23:57:50, and ends at 2021-08-06 23:57:50
```

In [128…
```
temp=None
temp = mta_data[(mta_data.datetime >= day_start) & (mta_data.datetime <= day_enc
temp.head()
```

Out[128…

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	datetime	
0	A002	R051	02-00-00	59 ST	NQR456W	BMT	2021-07-31	REGULAR	7611181	2603110	2021-07-31 00:00:00	R05
1	A002	R051	02-00-00	59 ST	NQR456W	BMT	2021-07-31	REGULAR	7611192	2603113	2021-07-31 04:00:00	R05
2	A002	R051	02-00-00	59 ST	NQR456W	BMT	2021-07-31	REGULAR	7611197	2603126	2021-07-31 08:00:00	R05

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	datetime	
3	A002	R051	02-00-00	59 ST	NQR456W	BMT	2021-07-31	REGULAR	7611235	2603178	2021-07-31 12:00:00	R05
4	A002	R051	02-00-00	59 ST	NQR456W	BMT	2021-07-31	REGULAR	7611357	2603211	2021-07-31 16:00:00	R05

In [129…
```
temp.shape
```

Out[129…
```
(2692324, 12)
```

Lets check for duplicates again:

In [130…
```
num_dups = temp[temp.duplicated(subset=['station', 'turnstile_id', 'datetime'])]
print("There are %d duplicates" % num_dups)
```

```
There are 12 duplicates
```

12 dupes! Lets have a look:

In [131…
```
dupes = temp[temp.duplicated(subset = ['station','turnstile_id','datetime'])]
dupes
```

Out[131…

	c_a	unit	scp	station	linename	division	date	desc	entries	exits
607345	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-22	RECOVR AUD	262243	0
607347	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-22	RECOVR AUD	262243	0
607351	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-22	RECOVR AUD	262243	0
607353	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-22	RECOVR AUD	262243	0
1334238	N213	R154	00-00-00	TREMONT AV	BD	IND	2021-06-23	RECOVR AUD	3682482	2760115
1334449	N213	R154	00-00-05	TREMONT AV	BD	IND	2021-06-23	RECOVR AUD	369307075	100833056
1347389	N335	R158	01-00-03	KEW GARDENS	EF	IND	2021-06-20	RECOVR AUD	5201960	17258853
1347432	N335	R158	01-00-04	KEW GARDENS	EF	IND	2021-06-20	RECOVR AUD	6718777	26526664
1347893	N336	R158	00-00-05	KEW GARDENS	EF	IND	2021-06-20	RECOVR AUD	8833758	2334263

	c_a	unit	scp	station	linename	division	date	desc	entries	exits
2270855	R314	R406	00-00-02	PROSPECT AV	25	IRT	2021-05-28	RECOVR AUD	67258361	16839157
2326757	C018	R197	00-00-04	36 ST	DNR	BMT	2021-05-18	RECOVR AUD	13017811	5510261
2386866	N310	R140	01-06-00	QUEENS PLAZA	EMR	IND	2021-05-20	RECOVR AUD	917544	17105542

Lets have a look at why the values were duplicated:

In [132…

```
LIMIT = 12
counter = 0

for ix,k in dupes.iterrows():
    print('==================Duplicate %d==================' % counter)
    print(temp[(temp.station == k.station)
               & (temp.turnstile_id == k.turnstile_id)
               & (temp.datetime == k.datetime)])
    print('================================================\n')
    counter += 1
    if counter > LIMIT:
        print("Reached limit of %d, terminating...." % LIMIT)
        break
```

```
==================Duplicate 0==================
         c_a  unit       scp       station linename division       date  \
607344  R514  R094  00-05-00  ASTORIA BLVD      NQW      BMT 2021-07-22
607345  R514  R094  00-05-00  ASTORIA BLVD      NQW      BMT 2021-07-22

              desc  entries  exits   datetime        turnstile_id
607344     REGULAR        3      0 2021-07-22  R094_R514_00-05-00
607345  RECOVR AUD   262243      0 2021-07-22  R094_R514_00-05-00
================================================

==================Duplicate 1==================
         c_a  unit       scp       station linename division       date  \
607346  R514  R094  00-05-00  ASTORIA BLVD      NQW      BMT 2021-07-22
607347  R514  R094  00-05-00  ASTORIA BLVD      NQW      BMT 2021-07-22

              desc  entries  exits            datetime        turnstile_id
607346     REGULAR        3      0 2021-07-22 04:00:00  R094_R514_00-05-00
607347  RECOVR AUD   262243      0 2021-07-22 04:00:00  R094_R514_00-05-00
================================================

==================Duplicate 2==================
         c_a  unit       scp       station linename division       date  \
607350  R514  R094  00-05-00  ASTORIA BLVD      NQW      BMT 2021-07-22
607351  R514  R094  00-05-00  ASTORIA BLVD      NQW      BMT 2021-07-22

              desc  entries  exits            datetime        turnstile_id
607350     REGULAR        3      0 2021-07-22 08:00:00  R094_R514_00-05-00
607351  RECOVR AUD   262243      0 2021-07-22 08:00:00  R094_R514_00-05-00
================================================

==================Duplicate 3==================
         c_a  unit       scp       station linename division       date  \
607352  R514  R094  00-05-00  ASTORIA BLVD      NQW      BMT 2021-07-22
```

```
607353  R514  R094  00-05-00  ASTORIA BLVD      NQW      BMT 2021-07-22

              desc  entries  exits            datetime        turnstile_id
607352     REGULAR        3      0 2021-07-22 12:00:00  R094_R514_00-05-00
607353  RECOVR AUD   262243      0 2021-07-22 12:00:00  R094_R514_00-05-00
==================================================

==================Duplicate 4==================
          c_a  unit       scp     station linename division       date  \
1334237  N213  R154  00-00-00  TREMONT AV       BD      IND 2021-06-23
1334238  N213  R154  00-00-00  TREMONT AV       BD      IND 2021-06-23

               desc  entries    exits            datetime        turnstile_id
1334237     REGULAR  3682483  2760115 2021-06-23 05:00:00  R154_N213_00-00-00
1334238  RECOVR AUD  3682482  2760115 2021-06-23 05:00:00  R154_N213_00-00-00
==================================================

==================Duplicate 5==================
          c_a  unit       scp     station linename division       date  \
1334448  N213  R154  00-00-05  TREMONT AV       BD      IND 2021-06-23
1334449  N213  R154  00-00-05  TREMONT AV       BD      IND 2021-06-23

               desc    entries      exits            datetime  \
1334448     REGULAR  369307076  100833056 2021-06-23 05:00:00
1334449  RECOVR AUD  369307075  100833056 2021-06-23 05:00:00

               turnstile_id
1334448  R154_N213_00-00-05
1334449  R154_N213_00-00-05
==================================================

==================Duplicate 6==================
          c_a  unit       scp      station linename division       date  \
1347388  N335  R158  01-00-03  KEW GARDENS       EF      IND 2021-06-20
1347389  N335  R158  01-00-03  KEW GARDENS       EF      IND 2021-06-20

               desc  entries     exits            datetime        turnstile_id
1347388     REGULAR  5201958  17258849 2021-06-20 18:30:00  R158_N335_01-00-03
1347389  RECOVR AUD  5201960  17258853 2021-06-20 18:30:00  R158_N335_01-00-03
==================================================

==================Duplicate 7==================
          c_a  unit       scp      station linename division       date  \
1347431  N335  R158  01-00-04  KEW GARDENS       EF      IND 2021-06-20
1347432  N335  R158  01-00-04  KEW GARDENS       EF      IND 2021-06-20

               desc  entries     exits            datetime        turnstile_id
1347431     REGULAR  6718777  26526659 2021-06-20 18:30:00  R158_N335_01-00-04
1347432  RECOVR AUD  6718777  26526664 2021-06-20 18:30:00  R158_N335_01-00-04
==================================================

==================Duplicate 8==================
          c_a  unit       scp      station linename division       date  \
1347892  N336  R158  00-00-05  KEW GARDENS       EF      IND 2021-06-20
1347893  N336  R158  00-00-05  KEW GARDENS       EF      IND 2021-06-20

               desc  entries    exits            datetime        turnstile_id
1347892     REGULAR  8833758  2334264 2021-06-20 18:30:00  R158_N336_00-00-05
1347893  RECOVR AUD  8833758  2334263 2021-06-20 18:30:00  R158_N336_00-00-05
==================================================

==================Duplicate 9==================
          c_a  unit       scp      station linename division       date  \
2270854  R314  R406  00-00-02  PROSPECT AV       25      IRT 2021-05-28
2270855  R314  R406  00-00-02  PROSPECT AV       25      IRT 2021-05-28
```

```
              desc   entries     exits            datetime  \
2270854     REGULAR  67258362  16839157 2021-05-28 05:00:00
2270855  RECOVR AUD  67258361  16839157 2021-05-28 05:00:00

              turnstile_id
2270854  R406_R314_00-00-02
2270855  R406_R314_00-00-02
==================================================

==================Duplicate 10==================
          c_a  unit       scp station linename division       date  \
2326756  C018  R197  00-00-04   36 ST      DNR      BMT 2021-05-18
2326757  C018  R197  00-00-04   36 ST      DNR      BMT 2021-05-18

              desc   entries    exits            datetime        turnstile_id
2326756     REGULAR  13017811  6034545 2021-05-18 09:00:00  R197_C018_00-00-04
2326757  RECOVR AUD  13017811  5510261 2021-05-18 09:00:00  R197_C018_00-00-04
==================================================

==================Duplicate 11==================
          c_a  unit       scp       station linename division       date  \
2386865  N310  R140  01-06-00  QUEENS PLAZA      EMR      IND 2021-05-20
2386866  N310  R140  01-06-00  QUEENS PLAZA      EMR      IND 2021-05-20

              desc  entries     exits            datetime        turnstile_id
2386865     REGULAR   928040    336006 2021-05-20 17:00:00  R140_N310_01-06-00
2386866  RECOVR AUD   917544  17105542 2021-05-20 17:00:00  R140_N310_01-06-00
==================================================
```

They all seem to be recovery audits.

Lets have a look at a 3 day range for ASTORIA BLVD, with one day (2021-07-21) in the middle

In [133…

```
temp[
    (temp.station == 'ASTORIA BLVD')
    & (temp.turnstile_id == 'R094_R514_00-05-00')
    & (temp.date >= '2021-07-19')
    & (temp.date <= '2021-07-23')
]
```

Out[133…

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	datetime	
607327	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-19	REGULAR	262232	0	2021-07-19 00:00:00	
607328	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-19	REGULAR	262232	0	2021-07-19 04:00:00	
607329	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-19	REGULAR	262232	0	2021-07-19 08:00:00	
607330	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-19	REGULAR	262232	0	2021-07-19 12:00:00	
607331	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-19	REGULAR	262232	0	2021-07-19 16:00:00	
607332	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-19	REGULAR	262232	0	2021-07-19 20:00:00	

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	datetime	
607333	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-20	REGULAR	262232	0	2021-07-20 00:00:00	I
607334	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-20	REGULAR	262232	0	2021-07-20 04:00:00	I
607335	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-20	REGULAR	262232	0	2021-07-20 08:00:00	I
607336	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-20	REGULAR	262232	0	2021-07-20 12:00:00	I
607337	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-20	REGULAR	262232	0	2021-07-20 16:00:00	I
607338	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-20	REGULAR	262232	0	2021-07-20 20:00:00	I
607339	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-21	REGULAR	2	0	2021-07-21 04:00:00	I
607340	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-21	REGULAR	2	0	2021-07-21 08:00:00	I
607341	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-21	REGULAR	2	0	2021-07-21 12:00:00	I
607342	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-21	REGULAR	3	0	2021-07-21 16:00:00	I
607343	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-21	REGULAR	3	0	2021-07-21 20:00:00	I
607344	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-22	REGULAR	3	0	2021-07-22 00:00:00	I
607345	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-22	RECOVR AUD	262243	0	2021-07-22 00:00:00	I
607346	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-22	REGULAR	3	0	2021-07-22 04:00:00	I
607347	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-22	RECOVR AUD	262243	0	2021-07-22 04:00:00	I
607348	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-22	REGULAR	3	0	2021-07-22 07:39:19	I
607349	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-22	REGULAR	3	0	2021-07-22 07:40:57	I

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	datetime	
607350	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-22	REGULAR	3	0	2021-07-22 08:00:00	I
607351	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-22	RECOVR AUD	262243	0	2021-07-22 08:00:00	I
607352	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-22	REGULAR	3	0	2021-07-22 12:00:00	I
607353	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-22	RECOVR AUD	262243	0	2021-07-22 12:00:00	I
607354	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-22	REGULAR	262243	0	2021-07-22 16:00:00	I
607355	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-22	REGULAR	262243	0	2021-07-22 20:00:00	I
607356	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-23	REGULAR	262245	0	2021-07-23 00:00:00	I
607357	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-23	REGULAR	262245	0	2021-07-23 04:00:00	I
607358	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-23	REGULAR	262245	0	2021-07-23 08:00:00	I
607359	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-23	REGULAR	262245	0	2021-07-23 12:00:00	I
607360	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-23	REGULAR	262245	0	2021-07-23 16:00:00	I
607361	R514	R094	00-05-00	ASTORIA BLVD	NQW	BMT	2021-07-23	REGULAR	262245	0	2021-07-23 20:00:00	I

Conclusion:

1. There are at least 12 duplicates, and all of them are 'Recovery Audits'
2. In a few cases, the recovery audit numbers are quite close to the regular audits, and can be used to replace
   them, e.g. station KEW GARDENS, unit R158, control area: N336, SCP: 00-00-05, date: 2021-06-20, time: 18:30 In this specific case, entries are 8833758 for both duplicated rows, exits is 2334264 for regular and 2334264 for the audit. So, just dropping the regular would work for cases like this
3. Dropping the regular wont help for cases like ASTORIA BLVD above, where there is a much larger difference. For cases like these, we need to calculate the time delta as well and make sure that the difference in entries is not extremely large E.g. For station ASTORIA BLVD, unit:

R094, control area: R514, scp: 00-05-00, the difference between entries on regular log at 2021-07-21, time 20:00:00 and recovery log at same date and time 00:00:00 is 262240, for a time delta of 4 hours. That translates to 18 people entering the same turnstile per second, which is not reasonable

Recommendation

1. For a unique combination of station and turnstile id, we can keep the last observation, since from the observation above, it is a recovery audit
2. For a unique combination of station and turnstile id, there is no need to keep a row that has the same number for exit, it doesnt add any value for the final metric, so this duplication can be deleted
3. We also need to check the exit delta against 14400. This is the number of people who can enter a turnstil in 4 hours if there is one person entering every second. If the exit delta is > than this, drop it
4. Last, we can also drop all rows with negative exit delta, from the conclusions of Experiment 1 above

2. Sort by station and turnstile id

In [135…
```
temp.sort_values(['station', 'turnstile_id','datetime'], inplace=True)
temp.head()
```

Out[135…

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	datetime
2545948	H007A	R248	02-00-00	1 AV	L	BMT	2021-05-09	RECOVR AUD	253606	39725	2021-05-09 00:00:00
2545949	H007A	R248	02-00-00	1 AV	L	BMT	2021-05-09	REGULAR	253623	39729	2021-05-09 04:00:00
2545950	H007A	R248	02-00-00	1 AV	L	BMT	2021-05-09	REGULAR	253634	39742	2021-05-09 08:00:00
2545951	H007A	R248	02-00-00	1 AV	L	BMT	2021-05-09	REGULAR	253746	39752	2021-05-09 12:00:00
2545952	H007A	R248	02-00-00	1 AV	L	BMT	2021-05-09	REGULAR	253939	39779	2021-05-09 16:00:00

3. Calculate exit delta

In [136…
```
temp['delta'] = temp.groupby(['station','turnstile_id']).exits.transform(lambda
temp.head()
```

Out[136…

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	datetime
2545948	H007A	R248	02-00-00	1 AV	L	BMT	2021-05-09	RECOVR AUD	253606	39725	2021-05-09 00:00:00

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	datetime
2545949	H007A	R248	02-00-00	1 AV	L	BMT	2021-05-09	REGULAR	253623	39729	2021-05-09 04:00:00
2545950	H007A	R248	02-00-00	1 AV	L	BMT	2021-05-09	REGULAR	253634	39742	2021-05-09 08:00:00
2545951	H007A	R248	02-00-00	1 AV	L	BMT	2021-05-09	REGULAR	253746	39752	2021-05-09 12:00:00
2545952	H007A	R248	02-00-00	1 AV	L	BMT	2021-05-09	REGULAR	253939	39779	2021-05-09 16:00:00

4. Filter exit deltas

1. Remove duplicated entries
2. Remove negative deltas
3. Check for positive deltas, and remove if not logical

In [137…
```
# Do we still have dupes
dupes = temp[temp.duplicated(subset=['station','turnstile_id','datetime'])]
dupes.shape
```

Out[137…
```
(12, 13)
```

In [138…
```
print("There are %d rows before" % temp.shape[0])
temp.drop_duplicates(subset=['station','turnstile_id','datetime'], keep='last',
print("There are %d rows after" % temp.shape[0])
```

```
There are 2692324 rows before
There are 2692312 rows after
```

In [139…
```
temp.delta.describe()
```

Out[139…
```
count    2.687285e+06
mean    -8.844527e+02
std      2.237110e+06
min     -1.875746e+09
25%      5.000000e+00
50%      2.900000e+01
75%      8.600000e+01
max      1.169855e+09
Name: delta, dtype: float64
```

In [140…
```
print("There are %d rows before dropping negative deltas" % temp.shape[0])
temp = temp[temp.delta >= 0]
print("There are %d rows after dropping negative deltas " % temp.shape[0])
```

```
There are 2692312 rows before dropping negative deltas
There are 2671092 rows after dropping negative deltas
```

Now lets check extremely large exit delta

In [141…
```
temp[temp.delta > 14400].turnstile_id.count()
```

Out[141… 54

54 extremely large values. We will check a few to see whats happening

In [142…
```
large = temp[temp.delta > 14400]
print(large.station.value_counts())
large = None
```

```
JOURNAL SQUARE     12
CITY / BUS          7
34 ST-PENN STA      6
NEWARK HM HE        4
GROVE STREET        3
THIRTY THIRD ST     3
THIRTY ST           3
QUEENS PLAZA        2
TWENTY THIRD ST     2
PAVONIA/NEWPORT     1
FORDHAM RD          1
BEACH 60 ST         1
36 ST               1
WORLD TRADE CTR     1
14TH STREET         1
HUNTS POINT AV      1
WHITEHALL S-FRY     1
AVENUE I            1
23 ST               1
RIT-ROOSEVELT       1
46 ST BLISS ST      1
Name: station, dtype: int64
```

In [144…
```
# JOURNAL SQUARE
large_js = temp[(temp.station == 'JOURNAL SQUARE')].copy()
large_idx = large_js[large_js.delta > 14400].sort_values('delta').head(1).index.
large_js[large_js.delta > 14400]
```

Out[144…

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	datetim
2214200	PTH03	R552	00-01-08	JOURNAL SQUARE	1	PTH	2021-05-24	REGULAR	31986	19635	2021-05 2 09:42:1
1795599	PTH03	R552	00-01-08	JOURNAL SQUARE	1	PTH	2021-06-09	REGULAR	34833	20754	2021-06 0 08:08:1
1795606	PTH03	R552	00-01-08	JOURNAL SQUARE	1	PTH	2021-06-10	REGULAR	35009	20817	2021-06 1 09:20:1
1586139	PTH03	R552	00-01-08	JOURNAL SQUARE	1	PTH	2021-06-14	REGULAR	35820	21163	2021-06 1 14:08:1
1586157	PTH03	R552	00-01-08	JOURNAL SQUARE	1	PTH	2021-06-17	REGULAR	36530	21362	2021-06 1 13:32:1
1377050	PTH03	R552	00-01-08	JOURNAL SQUARE	1	PTH	2021-06-21	REGULAR	37328	21670	2021-06 2 09:56:1
1167585	PTH03	R552	00-01-08	JOURNAL SQUARE	1	PTH	2021-06-29	REGULAR	38967	22271	2021-06 2 11:08:1

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	datetim
957697	PTH03	R552	00-01-08	JOURNAL SQUARE	1	PTH	2021-07-07	REGULAR	40615	22951	2021-0 0 12:20:1
957703	PTH03	R552	00-01-08	JOURNAL SQUARE	1	PTH	2021-07-08	REGULAR	40806	23030	2021-0 0 09:20:1
748135	PTH03	R552	00-01-08	JOURNAL SQUARE	1	PTH	2021-07-12	REGULAR	41654	23401	2021-0 1 09:56:1
748153	PTH03	R552	00-01-08	JOURNAL SQUARE	1	PTH	2021-07-15	REGULAR	42293	23632	2021-0 1 09:20:1
119648	PTH03	R552	00-01-08	JOURNAL SQUARE	1	PTH	2021-08-04	REGULAR	45927	25431	2021-0 0 12:08:2

In [145…
```
print(large_idx)
```

```
2214200
```

In [150…
```
idx = mta_data.index.get_loc(large_idx)
mta_data.loc[idx-1:idx+1,:]
```

Out[150…

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	datetim
2214199	PTH03	R552	00-01-08	JOURNAL SQUARE	1	PTH	2021-05-24	REGULAR	1	0	2021-05 2 09:01:4
2214200	PTH03	R552	00-01-08	JOURNAL SQUARE	1	PTH	2021-05-24	REGULAR	31986	19635	2021-05 2 09:42:1
2214201	PTH03	R552	00-01-08	JOURNAL SQUARE	1	PTH	2021-05-24	REGULAR	32015	19644	2021-05 2 13:54:1

Looks like an equipment malfunction. For the same station ('JOURNAL SQUARE') and same turnstile (unit: R552, control area: PTH_03 and scp: 00-01-08), 19635 people exited within less than 41 minutes. Thats almost 8 people in one second, too efficient to be true

In [151…
```
large_js=None
```

Lets look at the last one (46 ST BLISS ST)

In [152…
```
large_46 = temp[temp.station == '46 ST BLISS ST'].copy()
large_46[large_46.delta > 14400]
```

Out[152…

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	datetim
2075544	R520	R223	01-06-00	46 ST BLISS ST	7	IRT	2021-06-03	REGULAR	13942393	6714230	2021-0 0 12:00:0

In [155…

```
large_46[
    (large_46.turnstile_id == 'R223_R520_01-06-00')
    & (large_46.date >= '2021-06-03')
    & (large_46.date <= '2021-06-04')
]
```

Out[155…

	c_a	unit	scp	station	linename	division	date	desc	entries	exits	datetim
2075538	R520	R223	01-06-00	46 ST BLISS ST	7	IRT	2021-06-03	REGULAR	8899046	2117913	2021-0(00:00:0
2075539	R520	R223	01-06-00	46 ST BLISS ST	7	IRT	2021-06-03	REGULAR	8899046	2117913	2021-0(04:00:0
2075540	R520	R223	01-06-00	46 ST BLISS ST	7	IRT	2021-06-03	REGULAR	8899046	2117913	2021-0(07:19:1
2075541	R520	R223	01-06-00	46 ST BLISS ST	7	IRT	2021-06-03	REGULAR	8899046	2117913	2021-0(07:20:5
2075542	R520	R223	01-06-00	46 ST BLISS ST	7	IRT	2021-06-03	REGULAR	8899046	2117913	2021-0(08:00:0
2075543	R520	R223	01-06-00	46 ST BLISS ST	7	IRT	2021-06-03	REGULAR	8899046	2117913	2021-0(09:25:2
2075544	R520	R223	01-06-00	46 ST BLISS ST	7	IRT	2021-06-03	REGULAR	13942393	6714230	2021-0(12:00:0
2075545	R520	R223	01-06-00	46 ST BLISS ST	7	IRT	2021-06-03	REGULAR	13942732	6714322	2021-0(16:00:0
2075546	R520	R223	01-06-00	46 ST BLISS ST	7	IRT	2021-06-03	REGULAR	13943099	6714542	2021-0(20:00:0
2075547	R520	R223	01-06-00	46 ST BLISS ST	7	IRT	2021-06-04	REGULAR	13943214	6714703	2021-0(00:00:0
2075548	R520	R223	01-06-00	46 ST BLISS ST	7	IRT	2021-06-04	REGULAR	13943228	6714734	2021-0(04:00:0
2075549	R520	R223	01-06-00	46 ST BLISS ST	7	IRT	2021-06-04	REGULAR	13943648	6714745	2021-0(08:00:0
2075550	R520	R223	01-06-00	46 ST BLISS ST	7	IRT	2021-06-04	REGULAR	13944106	6714783	2021-0(12:00:0
2075551	R520	R223	01-06-00	46 ST BLISS ST	7	IRT	2021-06-04	REGULAR	13944489	6714873	2021-0(16:00:0
2075552	R520	R223	01-06-00	46 ST BLISS ST	7	IRT	2021-06-04	REGULAR	13944858	6715073	2021-0(20:00:0

Again, looking like a malfunction. For the same station ('46 ST BLISS ST') and same unit (R223), control area (R520) and scp (01-06-00), 4596317 people exited in the space of 2.5 hours. Thats approx. 510 people per second through that turnstile, which is only possible if its a warp gate from Infinity War: Endgame

Levity aside, it is assumed to be safe to drop large exit deltas

In [156…
```
print("There are %d rows before dropping large deltas" % temp.shape[0])
temp = temp[~(temp.delta > 14400)]
print("There are %d rows after dropping large deltas " % temp.shape[0])
```

```
There are 2671092 rows before dropping large deltas
There are 2671038 rows after dropping large deltas
```

In [159…
```
temp.describe()
```

Out[159…

	entries	exits	delta
count	2.671038e+06	2.671038e+06	2.671038e+06
mean	3.535034e+07	2.691020e+07	6.836206e+01
std	1.945606e+08	1.666237e+08	1.067823e+02
min	0.000000e+00	0.000000e+00	0.000000e+00
25%	2.145982e+05	9.473800e+04	5.000000e+00
50%	1.391515e+06	8.393260e+05	2.900000e+01
75%	5.909829e+06	3.872664e+06	8.700000e+01
max	2.147425e+09	2.061993e+09	1.183400e+04

5. Aggregate exit deltas

In [158…
```
result = temp.groupby('station')['delta'].sum().sort_values(ascending=False)
result
```

Out[158…
```
station
34 ST-PENN STA     5101817.0
34 ST-HERALD SQ    3910742.0
GRD CNTRL-42 ST    3837020.0
86 ST              3511981.0
14 ST-UNION SQ     3397784.0
                      ...
RIT-ROOSEVELT         5195.0
RIT-MANHATTAN         4304.0
ORCHARD BEACH          370.0
ST. GEORGE               6.0
TOMPKINSVILLE            1.0
Name: delta, Length: 379, dtype: float64
```

Not yet done, remember that this is for 90 days. Lets find the per day traffic for the first 5

In [166…
```
result = result / (day_end - day_start).days
result[:5]
```

Out[166…
```
station
34 ST-PENN STA     56686.855556
34 ST-HERALD SQ    43452.688889
GRD CNTRL-42 ST    42633.555556
```

```
86 ST              39022.011111
14 ST-UNION SQ     37753.155556
Name: delta, dtype: float64
```

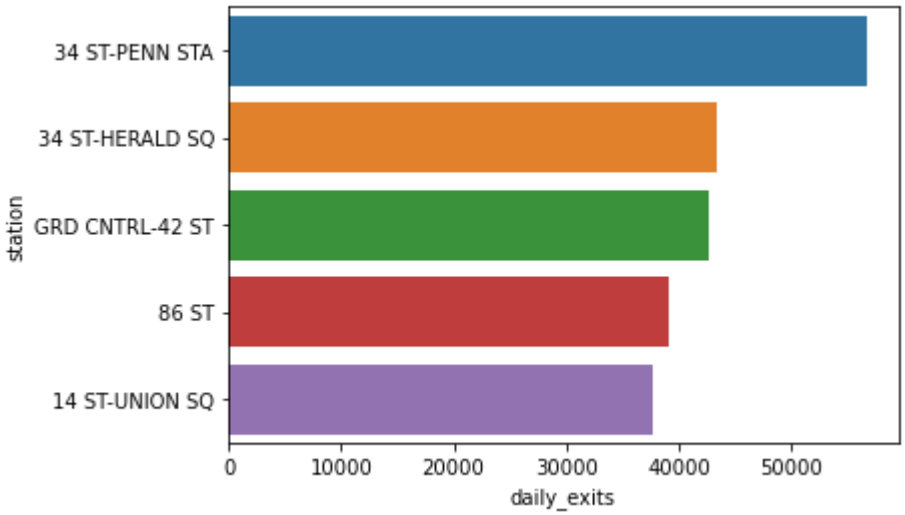
Conclusion

1. Busiest Stations

In [226…

```
import seaborn as sns
plot_result = result[:5].copy().to_frame()
plot_result.rename(columns={'delta':'daily_exits'},inplace=True)

myplot = sns.barplot(x=plot_result.daily_exits, y=plot_result.index)
```



These are the 5 busiest stations in order : '34 ST-PENN STA', '34 ST-HERALD SQ', 'GRD CNTRL-42 ST', '86 ST' and '14 ST-UNION SQ'

In [199…

```
plot_result = None
```

Notes

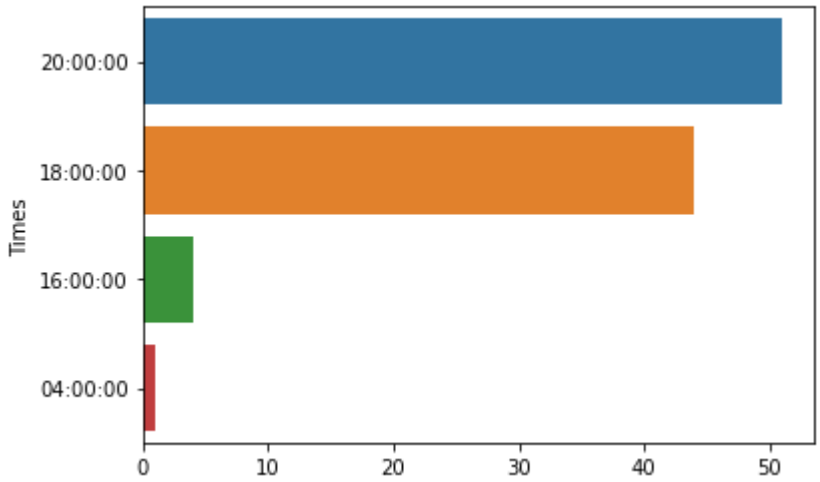
1. Incidentally, the station with the highest foot traffic, and the scond highest, are also included in results of Sidenote above, where we theorized that a station with the most number of turnstiles is likely to have the
   most traffic
2. This interesting tidbit about 34th Street in NYC, since our top 2 stations for exit foot traffic are on 34th street:
   `Several notable buildings are located directly along 34th Street, including the Empire State Building, Macy's Herald Square, and Javits Center.` -- wikipedia.org (2021-08-08)

2. Busiest times

Lets check the busiest times for the first 5 stations:

1. 34 ST-PENN STA

In [233…
```
temp1=None
temp1 = temp[temp.station == '34 ST-PENN STA'].sort_values('delta', ascending=Fa
temp1['times'] = temp1.datetime.dt.time
plot_s = temp1.times.value_counts()
plot_s.index.name = 'Times'
plot1 = sns.barplot(y=plot_s.index, x=plot_s.values)
```



In [234…
```
plot1 = None
```

Busiest times for the 2 stations on 34th street is 8pm, indicating that its probably a tourist spot/popular dining
spot. This may be a bit *inconvenient* for volunteers, but the volume of foot traffic would make it totally
worth it.

Busiest time for Grand Central and 42nd street is at 9:00am, which indicates that its probably an office/co-working spot, and thus, may **not** be the best spot for volunteers, since people exiting would be rushing to office

Busiest time for 86th street is 12:00pm, so it may be a popular lunch spot, and thus the perfect place to have volunteers at that time

Busiest time for 14th street and union square is 5pm, indicating that it may be a transit station for people
getting off from work. This may be an ok spot to have volunteers, not the best, since such people would be
relaxed, but also the least attentive

In [ ]:
```
```

Sidenote 2:

Ok, I'm curious, why does TOMPKINSVILLE have such low exit traffic?

In [200…
```
temp[temp.station == 'TOMPKINSVILLE'].exits.describe()
```

Out[200…
```
count     3773.000000
```

```
mean      9982.633448
std      22730.946782
min          0.000000
25%          2.000000
50%         12.000000
75%       4303.000000
max      65536.000000
Name: exits, dtype: float64
```

In [201…
```
temp[temp.station == 'TOMPKINSVILLE'].exits.value_counts()
```

Out[201…
```
4303     539
3        539
12       539
2        539
0        539
65536    539
22       305
23       234
Name: exits, dtype: int64
```

In [202…
```
temp[temp.station == 'TOMPKINSVILLE'].entries.value_counts()
```

Out[202…
```
654       170
262575    145
262600    124
262589     77
647        77
          ...
649742      1
678418      1
678420      1
645666      1
59876       1
Name: entries, Length: 2027, dtype: int64
```

Very few unique exit values, compared to entry values, and a lot of them seem stuck at the same number, indicating a possible defect with the exit counter

In [ ]:
```
```