Statistics (cdf, ppf, prf) t_test, z_test

In [1]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
```

In [2]:

```
t_mean = 18.7 # given
t_std = 5.8 # given
n_trips = 2000 #given
```

Question 1

In [3]:

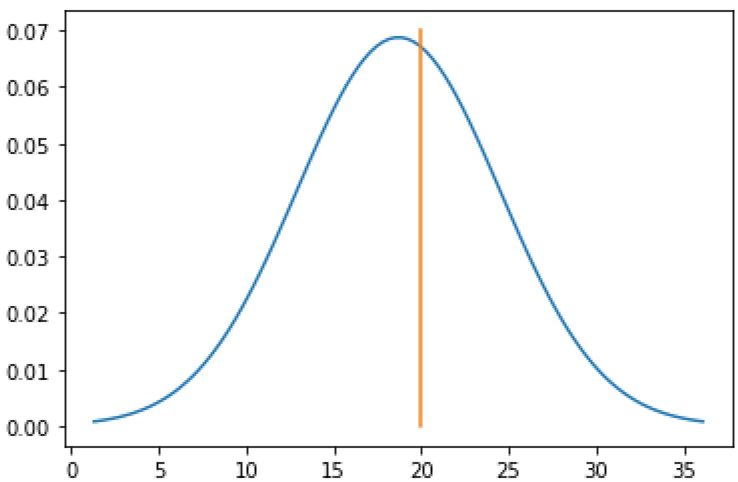
```
#Asked: should earn over 20
```

In [4]:

```
import scipy.stats as stats
```

In [5]:

```
x = np.linspace(t_mean-3*t_std, t_mean+3*t_std, 100)
plt.plot(x, stats.norm.pdf(x, t_mean, t_std));
plt.plot([20,20,20],[0,0.01,0.07]);
```



stats.norm.cdf

In [6]:

```
#The formula to find the left area of the curve until 20
stats.norm.cdf(20, t_mean, t_std)
```

Out[6]:

```
0.5886750107430825
```

In [7]:

```
# Then 1 - (above code) gives the right area of the curve
1-stats.norm.cdf(20, t_mean, t_std)
```

Out[7]:

```
0.4113249892569175
```

In [8]:

```
# Now multiplying by number of trips
#(Because above calculation was for only one unit trip)
2000*0.41
```

Out[8]: 820.0

stats.binom.cdf(x, n, p)

x is the number of successes from n trials with the probability of success is p

In [9]:
```
# Let's find the probability of successes of having two tails
# from three coin toss where p of having tails = 0.6
print(3*((0.6**2)*((1-0.6)**1)))
stats.binom.pmf(2,3,0.6)  # pmf returns the p of successes
```

```
0.43199999999999994
```

Out[9]: 0.43199999999999994

Question 3

In [10]:
```
n_trips = 5
# Asked: over 15 probability at least 3 trips out of 5 trips
right_area = 1 - stats.norm.cdf(15, t_mean, t_std)
```

In [11]:
```
#"binom.cdf(num_succ-1, num_trials, prob)" Excel -> "=BINOMDIST(B2,C2,D2,1)
```

In [12]:
```
print(right_area)
left_area = 1-right_area
print(left_area)
```

```
0.7382407127058933
0.2617592872941067
```

Usually dist formulas calculates left curve area so if we need to know right area, we have to 1- left_area

In [13]:
```
# This formula calculates the probability of having
# 2 or less success from 5 trial whose probability = left_area
stats.binom.cdf(2,5,left_area)
```

Out[13]: 0.8836952614939727

In [14]:
```
# Not having 2 or less successes from 5 trials where p = left_area
stats.binom.sf(2,5,left_area)
```

Out[14]: 0.11630473850602734

In [15]:
```
#Additional
# If we are asked to find successes between [2 and 4], for example
```

In [16]:
```
stats.binom.cdf(4,5,right_area)
```

Out[16]: 0.7807245754350454

In [17]:

```
stats.binom.cdf(1, 5, right_area)
```

Out[17]: 0.018557998317456286

In [18]:

```
# This formula equals to excel formula --> BINOM.DIST.RANGE(5,right_area,2,4)
stats.binom.cdf(4,5,right_area)-stats.binom.cdf(1, 5, right_area)
```

Out[18]: 0.7621665771175891

Question 2

In [19]:

```
n_trips = 5
# Asked: All of trip to get 15 or over
left_a = stats.norm.cdf(15, t_mean, t_std)
right_a = 1-left_a
```

In [20]:

```
stats.binom.cdf(0,5,left_a)
```

Out[20]: 0.21927542456495466

Question 8

Given:

$$p = 0.6$$

$$\hat{p} = 0.5$$

$$n = 50$$

Then:

$$var = \hat{p} * (1 - \hat{p})$$

$$std = \frac{\sqrt{var}}{\sqrt{n}}$$

$$z = \frac{(p - \hat{p})}{std}$$

$\hat{p}$ is a mean for Ha and p is from sample we got

from scipy.stats import norm

norm.cdf(1.96)

0.9750021048517795

norm.cdf(-1.96)

0.024997895148220435

stats.norm.ppf

In [21]:

```
# This formula will calculate z value, two-tail
# Where confidence interval for 99 %, z value is 2.575
```

```
stats.norm.ppf(0.995)
# It means that 99% confidence interval lies
#2.575 standard deviation from the mean
#where mean = 0 and std = 1
```

Out[21]: 2.5758293035489004

In [22]:

```
stats.norm.cdf(2.575)
# It will give the confidence interval of the given value
#(std of how many times far from the mean (z))
```

Out[22]: 0.9949879956682387

In [23]:

```
stats.norm.cdf(1.4142)
```

Out[23]: 0.9213484060057744

In [24]:

```
p_val = 1- stats.norm.cdf(1.4142)
p_val
```

Out[24]: 0.07865159399422561

Question 10

In [25]:

```
m = 85
std_sample = 32
n = 16
```

In [26]:

```
std_r = std_sample/np.sqrt(n)
```

In [27]:

```
z =stats.norm.ppf(0.95)
```

In [28]:

```
marg_errors = z*std_r
```

In [29]:

```
conf_int_min  = m-marg_errors
conf_int_max  = m+marg_errors
```

In [30]:

```
print(conf_int_min, 'to ', conf_int_max)
```

```
71.84117098438823 to  98.15882901561177
```

In [31]:

```
#Studnt, n=999, p<0.05, 2-tail\
#equivalent to Excel T.INV(0.05,999) or T.INV.2T(0.1, 999)
#90% confidence interval
#print stats.t.ppf(1-0.025, 999)

#Studnt, n=999, p<0.05%, Single tail\
#equivalent to Excel TINV(2*0.05,999)\
#print stats.t.ppf(1-0.05, 999)
```

In [32]:
```
#But t is used more
```

stats.t.ppf

In [33]:
```
t = stats.t.ppf(0.95,15)
marg_errors = std_r*t
conf_int_min  = m-marg_errors
conf_int_max  = m+marg_errors
print(conf_int_min, 'to ', conf_int_max)
```

```
70.97559715445956 to  99.02440284554044
```

Question 14

In [34]:
```
uber = pd.read_excel('data2.xlsx', sheet_name = 'Uber pay')
```

In [35]:
```
uber.head(2)
```

Out[35]:

	DriverID	City	Gender	Trips	Hourly Pay	Unnamed: 5
0	1	New York	Male	493	7.49	NaN
1	2	Boston	Male	1195	8.20	NaN

In [36]:
```
chic_mal = uber[(uber['City']=='Chicago')&(uber['Gender']=='Male')]['Hourly Pay']
```

In [37]:
```
std = chic_mal.std()
mean = chic_mal.mean()
n = len(chic_mal)
```

In [38]:
```
t = stats.t.ppf(0.975, 181)
std_n = std/np.sqrt(n)
```

In [39]:
```
marg_err = t*std_n
marg_err
```

Out[39]:
```
0.27923413996605523
```

Question 15

In [40]:
```
fem_pay = uber[uber['Gender']=='Female']['Hourly Pay']
```

In [41]:
```
mean = fem_pay.mean()
std = fem_pay.std()
n = len(fem_pay)
```

In [42]:
```
t = stats.t.ppf(0.975, n-1)
std_n = std/np.sqrt(n)
marg_err = t*std_n
conf_int_min = mean-marg_err
```

```
conf_int_max = mean+marg_err
print(conf_int_min, conf_int_max)
```

```
7.211959435480943 7.670625598532671
```

In [43]:
```
male = uber['Gender'].value_counts()[0]
female = uber['Gender'].value_counts()[1]
```

In [44]:
```
p = female/(male+female)
n = male+female
```

In [45]:
```
z = stats.norm.ppf(0.975)
```

In [46]:
```
t = stats.t.ppf(0.975, n-1)
```

In [47]:
```
std = np.sqrt(p*(1-p)/n)
```

In [48]:
```
marg_err = t*std
max_conf = p+marg_err
min_conf = p-marg_err
print(min_conf, max_conf)
```

```
0.2657283864579868 0.32227161354201317
```

Question 16

In [49]:
```
# Ho: m>= m_sample
# Ha: m< m_sample
```

In [50]:
```
population_mean = 7.25
sample_mean = uber['Hourly Pay'].mean()
alfa = 0.05
```

In [51]:
```
n = len(uber)
samp_std = uber['Hourly Pay'].std()
pop_std = samp_std/np.sqrt(n)
```

In [52]:
```
z = (sample_mean - population_mean)/pop_std
```

In [53]:
```
print(sample_mean)
print(samp_std)
n
```

```
7.893409999999993
1.9947413528989075
```

Out[53]:
```
1000
```

stats.t.cdf

In [54]:

```
p = 1 - stats.t.cdf(z, 999,0)
p
# we will reject the null H and agree with the Ha
# that uber driver earns more than pop_mean
```

Out[54]:

```
0.0
```

In [55]:

```
pop_std
```

Out[55]:

```
0.06307926018086264
```

In [56]:

```
stats.norm.cdf(7.89, 7.25, 0.06)
```

Out[56]:

```
1.0
```

Question 18

Two sample t test

In [57]:

```
chicago = uber[uber['City'] =='Chicago']['Hourly Pay']
york = uber[uber['City'] =='New York']['Hourly Pay']
```

In [58]:

```
ch_m = chicago.mean()
ch_std = chicago.std()
ch_n = len(chicago)
york_m = york.mean()
york_std = york.std()
york_n = len(york)
```

$$t = \frac{m1 - m2}{\sqrt{\frac{s1^2}{n1} + \frac{s2^2}{n2}}}$$

In [59]:

```
print(ch_m, ch_std, ch_n, york_m, york_std, york_n)
```

```
8.071140684410652 1.998541508080747 263 7.882751842751838 1.9597766271731287 407
```

In [60]:

```
# Ho: ch_m <= york_m
# Ha: ch_m > york_m
t = (ch_m-york_m) / np.sqrt((ch_std**2)/ch_n + (york_std**2)/york_n)
```

In [61]:

```
stats.t.cdf(t, ch_n+york_n-2)
```

Out[61]:

```
0.8848237669591617
```

In [62]:

```
# just another example:
```

In [63]:

```
#Blackboard: Given:
m1 = 82
s1 = 2.4
```

```
n1 = 15

m2 = 84
s2 = 1.7
n2 = 12
alfa = 0.05
```

In [64]:
```
t = (m1-m2)/np.sqrt((s1**2)/n1 + (s2**2)/n2)
t
```

Out[64]:
```
-2.5301595052287063
```

In [65]:
```
p = stats.t.cdf(t, 25)
```

In [66]:
```
# It is two tail test, because m1 != m2 (either high or low)
# So alfa = alfa/2 = 0.025
print(p)
alfa/2
```

```
0.00903684801412631
```

Out[66]:
```
0.025
```

**p is lower than alfa, so we reject Ho and accept Ha, which is:

there is signicant difference between mean1 and mean2**

In [67]:
```
hotel = pd.read_excel('data2.xlsx', sheet_name = 'hotel')
```

In [68]:
```
hotel.head()
```

Out[68]:

	BookingID	Channel	Weekday	Rate	Cancelled
0	1	Online	Tuesday	385.56	False
1	2	Online	Wednesday	305.15	False
2	3	Online	Thursday	559.00	True
3	4	Online	Monday	424.15	False
4	5	Online	Sunday	459.00	True

Question 19

In [69]:
```
rate = hotel['Rate']
```

In [70]:
```
r_m = rate.mean()
r_s = rate.std()
r_n = len(rate)
```

In [71]:
```
# Asked: build 95% confidence interval for rate
z = stats.norm.ppf(0.975)
t = stats.t.ppf(0.975, 999)
print(z, t)
```

```
1.959963984540054 1.9623414611334487
```

In [72]:
```
pop_std = r_s/np.sqrt(r_n)
```

In [73]:
```
marg_er = pop_std*z
```

In [74]:
```
min_conf = r_m -marg_er
max_conf = r_m + marg_er
print(min_conf, max_conf)
```

```
295.33095035193713 304.31864679106235
```

In [75]:
```
marg_er = pop_std*t
min_conf = r_m -marg_er
max_conf = r_m + marg_er
print(min_conf, max_conf)
```

```
295.3254992216916 304.3240979213079
```

Question 20

In [76]:
```
# alfa = 0.05
# Ho: r_m <= 300
# Ha: r_m > 300
```

In [77]:
```
t = (r_m-300)/pop_std # We should (x-x_mean)/(std/sqrt(n))
```

In [78]:
```
p = stats.t.cdf(t, 999) # to find how much area it will
# cover when the distance from mean is equal to t*std
```

In [79]:
```
p
```

Out[79]:
```
0.4695529077738393
```

Question 21

In [80]:
```
online = hotel[hotel['Channel']=='Online']['Rate']
offline = hotel[hotel['Channel']!='Online']['Rate']
```

In [81]:
```
of_mean = offline.mean()
of_std = offline.std()
of_len = len(offline)
on_mean = online.mean()
on_std = online.std()
on_len = len(online)
```

In [82]:
```
# Ho: of_mean >= on_mean
# Ha: of_mean < on_mean
alpha = 0.05
```

In [83]:

```
t = (of_mean-on_mean)/np.sqrt(of_std**2/of_len + on_std**2/on_len)
```

In [84]:

```
stats.t.cdf(t, of_len+on_len-2) # p value is higher than alpha
```

Out[84]:

```
0.2890174472520236
```

Question 22

In [85]:

```
hotel[hotel['Channel']=='Online'][['Rate',
                                   'Cancelled']].groupby('Cancelled').count()
```

Out[85]:

	Rate
Cancelled	
False	611
True	224

In [86]:

```
cancelled = 224
not_cancelled = 611
percent = 20
# Let's start
p_pop = 0.20
p_sample = cancelled/(cancelled+not_cancelled)
n = cancelled+not_cancelled
std = np.sqrt(p_pop*(1-p_pop)/n)
z = (p_sample - p_pop)/std
z
```

Out[86]:

```
4.9314158489676245
```

In [87]:

```
# Ho: p_sample =< 0.2
# Ha: p_sample > 0.2
alpha = 0.05
upper_bound = 0.95
```

In [88]:

```
print(p_sample, std)
```

```
0.2682634730538922 0.013842570804119656
```

In [89]:

```
p = stats.norm.cdf(z)
```

In [90]:

```
# stats.binom.cdf(p_sample, 0.2, std) is different thing,
# we can't use. (above)
stats.norm.cdf(p_sample*100, p_pop*100, std*100)
```

Out[90]:

```
0.9999995918213253
```

In [91]:

```
p # it is higher than upper bound, so we reject null H,
# therefore p_sample is higher than 0.2
```

Out[91]:

```
0.9999995918213253
```

Question 23

In [92]:
```
stats.norm.cdf(6,8,12) # area until 6 so 1- ..
# gives the area starting from 6 till end
```
Out[92]:
```
0.43381616738909634
```
In [93]:
```
stats.norm.cdf(6,15,30) # the same like above
```
Out[93]:
```
0.3820885778110474
```

Question 24

In [94]:
```
1-stats.norm.cdf(40,32.4, 3.6) # over 40
```
Out[94]:
```
0.017381381311114222
```

Question 25

In [95]:
```
stats.norm.ppf(0.75, 32.4, 3.6)
# gives the percentile (counter cdf)
# it gives 75% point where mean = 32.4 and std = 3.6
```
Out[95]:
```
34.82816310070589
```

Question 26

In [96]:
```
z_m = 8
z_s = 12
c_m = 15
c_s = 30
```
In [97]:
```
m_diff = z_m-c_m
s_diff = np.sqrt(z_s**2 + c_s**2)
z = m_diff/s_diff
#Asked:  when m_diff < 0
```
In [98]:
```
m_diff
```
Out[98]:
```
-7
```
In [99]:
```
stats.norm.cdf(0, m_diff, s_diff) # it is when m_diff < 0
```
Out[99]:
```
0.5857573222326861
```
In [100…
```
stats.norm.cdf(z)
```
Out[100…
```
0.41424267776731394
```

Question 27

In [101…

```
n = 8
price = 30
mean = 0.08
std = 0.12
total = 400
```

In [102…

```
single = total/n
single
```

Out[102… 50.0

In [103…

```
stats.norm.cdf(50, 32.4, 3.6) # till 50
1-stats.norm.cdf(50, 32.4, 3.6) # over 50
# almost 0
```

Out[103… 5.070335422630023e-07

In [104…

```
c_price = 30
c_mean= 0.08
c_std = 0.12
z_price = 40
z_mean = 0.15
z_std = 0.3
minimize = 50
n_share = 20
```

In [105…

```
stats.norm.ppf(0.5, 32.4, 3.6)
```

Out[105… 32.4

In [106…

```
new_df=pd.DataFrame(np.arange(1,21))
```

In [107…

```
new_df['zoom_price'] = z_price
new_df['zoom_mean'] = z_mean
new_df['zoom_std'] = z_std
new_df['cloud_price'] = c_price
new_df['cloud_mean'] = c_mean
new_df['cloud_std'] = c_std
```

In [108…

```
new_df = new_df.rename(columns= {0:'share_count'})
```

In [109…

```
new_df['zoom_return'] = new_df['share_count']*(new_df['zoom_price']+
                                               new_df['zoom_price']*new_df['zoom_mean'])
```

In [110…

```
new_df['zoom_return_std'] = np.sqrt(new_df['zoom_std']**2*new_df['share_count'])
```

In [111…

```
new_df['cloud_return'] = new_df['share_count']*(new_df['cloud_price']+
                                                new_df['cloud_price']*new_df['cloud_mean']
new_df['cloud_return_std'] = np.sqrt(new_df['cloud_std']**2*new_df['share_count'])
```

In [112...

```
new_df
```

Out[112...

	share_count	zoom_price	zoom_mean	zoom_std	cloud_price	cloud_mean	cloud_std	zoom_return	zo
0	1	40	0.15	0.3	30	0.08	0.12	46.0	
1	2	40	0.15	0.3	30	0.08	0.12	92.0	
2	3	40	0.15	0.3	30	0.08	0.12	138.0	
3	4	40	0.15	0.3	30	0.08	0.12	184.0	
4	5	40	0.15	0.3	30	0.08	0.12	230.0	
5	6	40	0.15	0.3	30	0.08	0.12	276.0	
6	7	40	0.15	0.3	30	0.08	0.12	322.0	
7	8	40	0.15	0.3	30	0.08	0.12	368.0	
8	9	40	0.15	0.3	30	0.08	0.12	414.0	
9	10	40	0.15	0.3	30	0.08	0.12	460.0	
10	11	40	0.15	0.3	30	0.08	0.12	506.0	
11	12	40	0.15	0.3	30	0.08	0.12	552.0	
12	13	40	0.15	0.3	30	0.08	0.12	598.0	
13	14	40	0.15	0.3	30	0.08	0.12	644.0	
14	15	40	0.15	0.3	30	0.08	0.12	690.0	
15	16	40	0.15	0.3	30	0.08	0.12	736.0	
16	17	40	0.15	0.3	30	0.08	0.12	782.0	
17	18	40	0.15	0.3	30	0.08	0.12	828.0	
18	19	40	0.15	0.3	30	0.08	0.12	874.0	
19	20	40	0.15	0.3	30	0.08	0.12	920.0	

In [113...

```
drive = pd.read_excel('data2.xlsx',
                      sheet_name= 'drive-through')
```

In [114...

```
drive
```

Out[114...

	Customer	Time
0	1	138.6
1	2	43.3
2	3	57.5
3	4	84.2
4	5	44.7
...	...	...
195	196	88.4
196	197	198.4
197	198	36.9
198	199	47.6

	Customer	Time
199	200	50.7

200 rows × 2 columns

Question 29

In [115…
```
st_err = stats.sem(drive['Time']) # standard error
st_err
```
Out[115…
```
4.7617343188819445
```
In [116…
```
drive['Time'].std()/np.sqrt(len(drive))
# equialent for std_error = std/sqrt(n)
```
Out[116…
```
4.7617343188819445
```

1 st way for confidence interval when alpha = 0.90

In [117…
```
mean= drive['Time'].mean()
```
In [118…
```
t = stats.t.ppf(0.95, len(drive) - 1)
```
In [119…
```
marg_err = t*st_err
```
In [120…
```
mean-marg_err
```
Out[120…
```
89.31801144522497
```
In [121…
```
mean+marg_err
```
Out[121…
```
105.05598855477506
```

2 nd way for confidence interval when alpha = 0.90

In [122…
```
stats.t.interval(alpha = 0.9,
                 df = len(drive)- 1,
                 loc = np.mean(drive['Time']),
                 scale = stats.sem(drive['Time']))
```
Out[122…
```
(89.31801144522497, 105.05598855477506)
```

Question 30

In [123…
```
light = pd.read_excel('data2.xlsx', sheet_name = 'lightbulbs')
```
In [124…
```
light.head()
```

Out[124...

	Lightbulb	Lifetime
0	1	840.08
1	2	960.00
2	3	953.38
3	4	981.14
4	5	938.66

In [125...

```
# Ho: life <= 1000;
# Ha: life > 1000;
alpha = 0.05
```

1st way

In [126...

```
mean = light['Lifetime'].mean()
std = light['Lifetime'].std()
n = len(light)
pop_std = std/np.sqrt(n)
```

In [127...

```
t = (mean -1000)/pop_std
t
```

Out[127...

```
-1.0303562006210676
```

In [128...

```
stats.t.cdf(t, n-1)
# this tells us that
# sample_mean - pop_mean < 0 has the area of 0.15,
# so 1- p gives the area of sample_mean-pop_mean> 0
1- stats.t.cdf(t, n-1) # this is final p value
```

Out[128...

```
0.8473232451095432
```

second way

In [129...

```
stats.ttest_1samp(light['Lifetime'],
                  1000,
                  alternative = 'greater')
```

Out[129...

```
Ttest_1sampResult(statistic=-1.0303562006210678, pvalue=0.8473232451095432)
```

Question 31:

In [130...

```
battery = pd.read_excel('data2.xlsx', sheet_name = 'battery')
```

In [131...

```
# Ho: brand_1 = brand2
# Ha: brand1 != brand2
alpha = 0.05
```

1st:

In [132…
```
battery.columns = ['battery', 'brand_1', 'brand_2']
```

In [133…
```
b1_mean=battery['brand_1'].mean()
b1_std = battery['brand_1'].std()
b2_mean=battery['brand_2'].mean()
b2_std = battery['brand_2'].std()
b1_len = len(battery['brand_1'])
b2_len = len(battery['brand_2'])
```

In [134…
```
t = (b1_mean - b2_mean)/np.sqrt(b1_std**2/ b1_len + b2_std**2/b2_len)
```

In [135…
```
t
```

Out[135…
```
0.7677462249616107
```

In [136…
```
print(1 -stats.t.cdf(t, b1_len +b2_len -2))
# alpha = 0.05/0.95 so we won't reject the null H;
# There is no signifiant difference
print((1 -stats.t.cdf(t, b1_len +b2_len -2))*2)
```

```
0.22177628637630398
0.44355257275260795
```

2nd:

In [137…
```
stats.ttest_ind(battery['brand_1'],
                battery['brand_2'],
                alternative = 'two-sided')
# p value is 0.46, so divided by two (two_sided)
```

Out[137…
```
Ttest_indResult(statistic=0.76774622496159, pvalue=0.4435525727526203)
```

In [138…
```
df = pd.DataFrame({'col_1':[10, 9, 11, 8, 14, 6],
                   'col_2':[11, 12, 7, 10, 8,13]})
```

In [139…
```
mean_1 = df['col_1'].mean()
std_1 = df['col_1'].std()
n_1 = len(df)
mean_2 = df['col_2'].mean()
std_2 = df['col_2'].std()
n_2 = len(df)
```

In [140…
```
t = (mean_1 - mean_2)/np.sqrt(std_1**2/n_1 + std_2**2/n_2)
p = stats.t.cdf(t, n_1+n_2-2)
print(t, p)
```

```
-0.34188172937891387 0.3697579336002253
```

In [141…
```
stats.ttest_ind(df['col_1'],
                df['col_2'],
                alternative='two-sided')
```

Out[141…
```
Ttest_indResult(statistic=-0.34188172937891387, pvalue=0.7395158672004506)
```

Question 33

In [142…
```
train = pd.read_excel('data2.xlsx', sheet_name = 'training')
train.head(3)
```

Out[142…

	Employee	Score_Before	Score_After
0	1	84	84
1	2	66	85
2	3	84	87

In [143…
```
before = train['Score_Before']
after = train['Score_After']
```

1st:

In [144…
```
b_m = before.mean()
b_s = before.std()
a_m = after.mean()
a_s = after.std()
n = len(before)
```

In [145…
```
t = (b_m - a_m)/np.sqrt(b_s**2/n + a_s**2/n)
```

In [146…
```
t
```

Out[146…
```
-7.241961961405006
```

In [147…
```
1-stats.t.cdf(t, 2*n-2)
```

Out[147…
```
0.9999999998640184
```

2nd

In [148…
```
stats.ttest_ind(before, after, alternative = 'greater')
```

Out[148…
```
Ttest_indResult(statistic=-7.241961961405005, pvalue=0.9999999998640184)
```

In [149…
```
!jupyter nbconvert --to webpdf  Assign_cdf.ipynb
```

```
[NbConvertApp] Converting notebook Assign_cdf.ipynb to webpdf
[NbConvertApp] Writing 474545 bytes to Assign_cdf.pdf
```