ANOVA test

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Clear workspace

```
clear all; clc; close all;
```

Aux (just to plot the distribution with more data)

Initialize data

```
aux = 3*rand(50000,1);
purchase_amt = zeros(50000,1);
offers = cell(50000,1);
offers_int = zeros(50000,1);
for ii = 1:length(aux)
    if aux(ii) < 1
        offers{ii} = "offer1";
        offers_int(ii) = 1;
        purchase_amt(ii) = normrnd(80,30);
    elseif aux(ii) < 2
        offers{ii} = "offer2";
        offers_int(ii) = 2;
        purchase_amt(ii) = normrnd(85,30);
    else
        offers{ii} = "nooffer";
        purchase_amt(ii) = normrnd(40,30);
    end
end

purchase_amt(purchase_amt<0) = 0;
```

Check that we have no negative values

```
min(purchase_amt)
```

```
ans = 0
```

```
% Number of values corrected to 0
numel(purchase_amt(purchase_amt==0))
```

```
ans = 1647
```

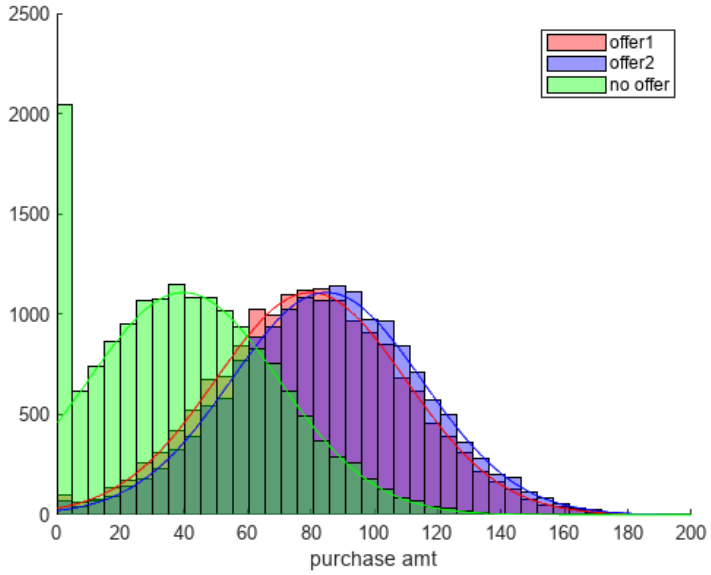
Explore data

Plot the distributions

```
binedges = linspace(0, ceil(max(purchase_amt)), ceil(max(purchase_amt)/5));

figure(1)
```

```
hold on
h1 = histogram(purchase_amt(offers_int==1), 'BinEdges', binedges, FaceColor='r', FaceAlpha=0.4)
h2 = histogram(purchase_amt(offers_int==2), 'BinEdges', binedges, FaceColor='b', FaceAlpha=0.4)
h3 = histogram(purchase_amt(offers_int==0),'BinEdges', binedges, FaceColor='g', FaceAlpha=0.4);
plot([0:.5:200],50000/3*5*normpdf([0:.5:200],80,30),'r-')
plot([0:.5:200],50000/3*5*normpdf([0:.5:200],85,30),'b-')
plot([0:.5:200],50000/3*5*normpdf([0:.5:200],40,30),'g-')
xlim([0,200])
xlabel('purchase amt')
hold off
legend('offer1','offer2','no offer')
% saveas(gcf,'01_ANOVA/ANOVA_hist_2.png')
```



Initialize variables

```
aux = 3*rand(500,1);
purchase_amt = zeros(500,1);
offers = cell(500,1);
offers_int = zeros(500,1);
for ii = 1:length(aux)
    if aux(ii) < 1
        offers{ii} = "offer1";
        offers_int(ii) = 1;
        purchase_amt(ii) = normrnd(80,30);
    elseif aux(ii) < 2
        offers{ii} = "offer2";
        offers_int(ii) = 2;
        purchase_amt(ii) = normrnd(85,30);
    else
        offers{ii} = "nooffer";
        purchase_amt(ii) = normrnd(40,30);
    end
end
```

```
purchase_amt(purchase_amt<0) = 0;
```

Check that we have no negative values

```
min(purchase_amt)
```

```
ans = 0
```

```
% Number of values corrected to 0
numel(purchase_amt(purchase_amt==0))
```

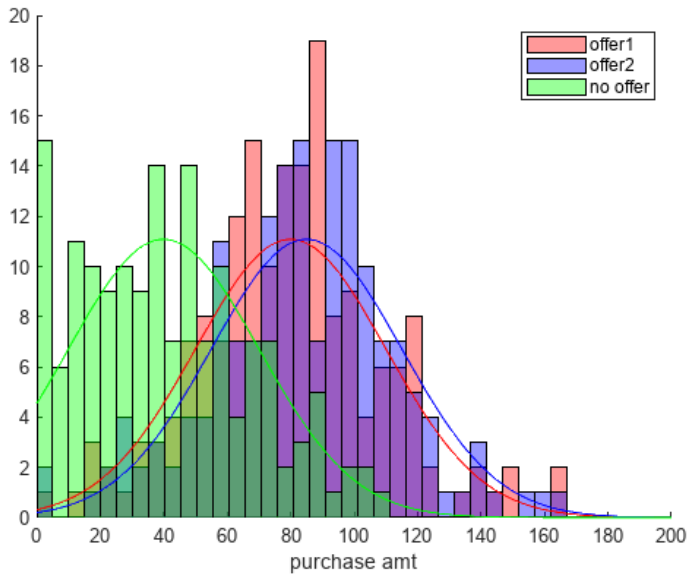
```
ans = 13
```

Explore data

Plot the distributions

```
binedges = linspace(0, ceil(max(purchase_amt)), ceil(max(purchase_amt)/5));

figure(2)
hold on
h1 = histogram(purchase_amt(offers_int==1), 'BinEdges', binedges, FaceColor='r', FaceAlpha=0.4)
h2 = histogram(purchase_amt(offers_int==2), 'BinEdges', binedges, FaceColor='b', FaceAlpha=0.4)
h3 = histogram(purchase_amt(offers_int==0),'BinEdges', binedges, FaceColor='g', FaceAlpha=0.4);
plot([0:.5:200],500/3*5*normpdf([0:.5:200],80,30),'r-')
plot([0:.5:200],500/3*5*normpdf([0:.5:200],85,30),'b-')
plot([0:.5:200],500/3*5*normpdf([0:.5:200],40,30),'g-')
xlim([0,200])
xlabel('purchase amt')
hold off
legend('offer1','offer2','no offer')
% saveas(gcf,'01_ANOVA/ANOVA_hist_1.png')
```

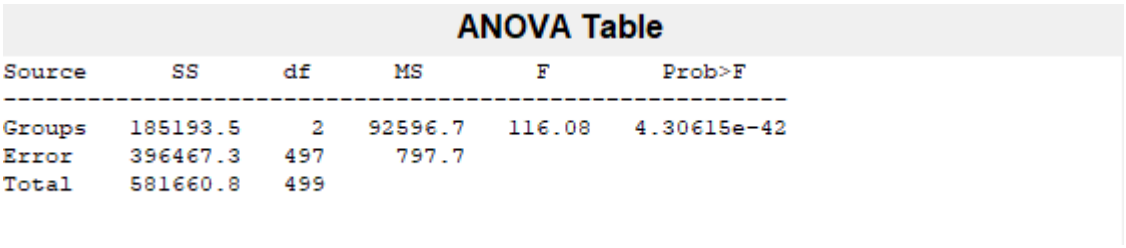


ANOVA tests

MATLAB built-in function

```
% a = purchase_amt(offers_int==1);
% b = purchase_amt(offers_int==2);
% c = purchase_amt(offers_int==0);
%
% n = min([size(a,1),size(b,1),size(c,1)])
%
% [p, tbl, stats] = anova1([a(1:n) b(1:n) c(1:n)])
%
% multcompare(stats)

[p, tbl, stats] = anova1(purchase_amt(:),offers_int(:))
```

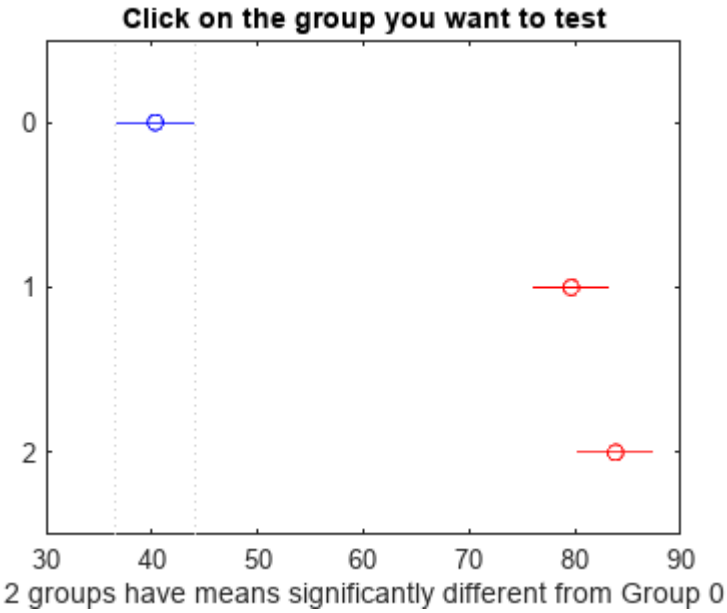



```
p = 4.3061e-42
tbl = 4×6 cell
```

	1	2	3	4	5	6
1	'Source'	'SS'	'df'	'MS'	'F'	'Prob>F'
2	'Groups'	1.8519e+05	2	9.2597e+04	116.0766	4.3061e-42
3	'Error'	3.9647e+05	497	797.7209	[ ]	[ ]
4	'Total'	5.8166e+05	499	[ ]	[ ]	[ ]

```
stats = struct with fields:
    gnames: {3×1 cell}
         n: [156 175 169]
    source: 'anova1'
     means: [40.3237 79.6492 83.8138]
        df: 497
         s: 28.2440
```

```
multcompare(stats)
```




```
ans = 3×6
    1.0000    2.0000  -46.6144  -39.3255  -32.0366         0
    1.0000    3.0000  -50.8397  -43.4901  -36.1405         0
    2.0000    3.0000  -11.3037   -4.1645    2.9746    0.3582
```

Explicit computation

```
X = purchase_amt;
groups = offers_int;

diff_groups = unique(groups);
k = size(diff_groups,1);
n = size(offers,1);

% Compute Means
mean_all = mean(X);
mean_between = zeros(k,1);
n_group = zeros(k,1);
for ii = 1:k
    mean_between(ii) = mean(X(groups==diff_groups(ii)));
    for jj = 1:n
        if X(groups(jj)==diff_groups(ii))
            n_group(ii) = n_group(ii) + 1;
        end
    end
end

% Between samples row
dfb = k-1;
SSb = 0;
for ii = 1:k
    SSb = SSb + n_group(ii)*(mean_between(ii) - mean_all)^2;
end
MSb = SSb/dfb;
```

```
% Within samples row
dfw = n - k;
SSw = 0;
for ii = 1:n
    for jj = 1:k
        if groups(ii) == diff_groups(jj)
            SSw = SSw + (mean_between(jj) - X(ii))^2;
        end
    end
end
MSw = SSw/dfw;

% Total row
SSt = SSb + SSw;
df = n - 1;

% F-static
F = MSb/MSw
```

```
F = 116.0766
```

```
% p>F
p = fcdf(F,dfb,dfw,'upper')
```

```
p = 4.3061e-42
```

```
Source = ['Group'; 'Error'; 'Total'];
SS = [SSb; SSw; SSt];
df = [dfb; dfw; df];
MS = [MSb; MSw; 0];
F_ = [F; 0; 0];
prob_F = [p; 0; 0];

anova = table(Source, SS, df, MS, F_, prob_F)
```

anova = 3×6 table

	Source	SS	df	MS	F_	prob_F
1	Group	1.8519e+05	2	9.2597e+04	116.0766	4.3061e-42
2	Error	3.9647e+05	497	797.7209	0	0
3	Total	5.8166e+05	499	0	0	0

Avoiding loops

```
diff_groups = unique(offers_int);
k = size(diff_groups,1);
n = size(offers,1);
```

```
dfb = k-1;
dfw = n - k;
df = n - 1;

a = purchase_amt(offers_int==0);
b = purchase_amt(offers_int==1);
c = purchase_amt(offers_int==2);

SSb = ((size(a,1)*(mean(a)-mean([a;b;c]))^2 + ...
        size(b,1)*(mean(b)-mean([a;b;c]))^2 + ...
        size(c,1)*(mean(c)-mean([a;b;c]))^2 ));
SSw = ( (size(a,1)-1) * var(a) + ...
        (size(b,1)-1) * var(b) + ...
        (size(c,1)-1) * var(c) );
SSt = SSb + SSw;

MSb = SSb/dfb;
MSw = SSw/dfw;

F = MSb/MSw
```

```
F = 116.0766
```

```
p = fcdf(F,dfb,dfw,'upper')
```

```
p = 4.3061e-42
```

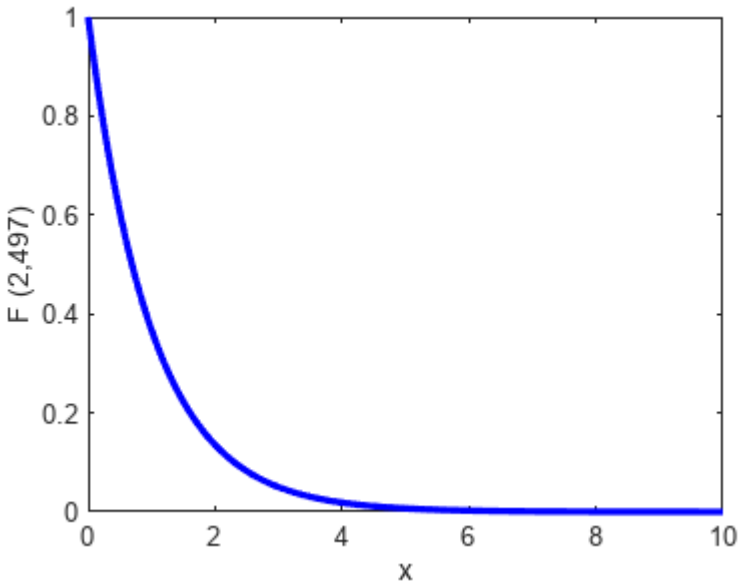
```
f = figure(5)
```

```
f =
  Figure (EmbeddedFigure_Internal) with properties:

      Number: 5
        Name: ''
       Color: [1 1 1]
    Position: [403 246 560 420]
       Units: 'pixels'

  Show all properties
```

```
plot([0:0.01:10],fpdf([0:0.01:10],dfb,dfw),'b',LineWidth=2.5)
ylabel(strcat('F (',num2str(dfb),',',num2str(dfw),')'))
xlabel('x')
% saveas(gcf,'01_ANOVA/f_distrib.png')
```




```
Source = ['Group'; 'Error'; 'Total'];
SS = [SSb; SSw; SSt];
df = [dfb; dfw; df];
MS = [MSb; MSw; 0];
F_ = [F; 0; 0];
prob_F = [p; 0; 0];

anova = table(Source, SS, df, MS, F_, prob_F)
```

anova = 3×6 table

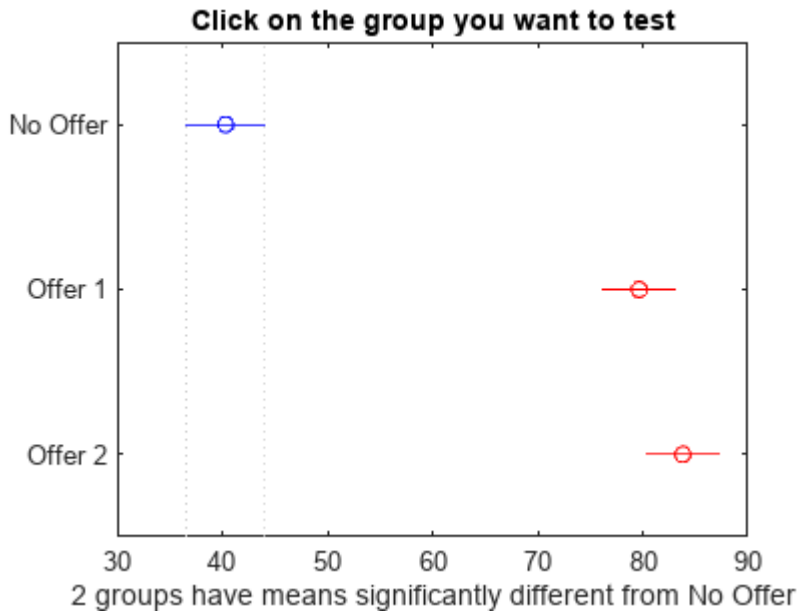
	Source	SS	df	MS	F_	prob_F
1	Group	1.8519e+05	2	9.2597e+04	116.0766	4.3061e-42
2	Error	3.9647e+05	497	797.7209	0	0
3	Total	5.8166e+05	499	0	0	0

```
stats = struct;
stats.gnames={'No Offer', 'Offer 1', 'Offer 2'}';
stats.n=[size(a,1), size(b,1), size(c,1)];
stats.source='anova1';
stats.means= [mean(a), ...
              mean(b), ...
              mean(c) ];
stats.df= dfw;
stats.s=mean([std(a), ...
              std(b), ...
              std(c)]);

stats
```

```
stats = struct with fields:
    gnames: {3×1 cell}
         n: [156 175 169]
    source: 'anova1'
     means: [40.3237 79.6492 83.8138]
        df: 497
         s: 28.1769
```

```
multcompare(stats)
```




```
ans = 3×6
    1.0000    2.0000  -46.5971  -39.3255  -32.0539         0
    1.0000    3.0000  -50.8222  -43.4901  -36.1579         0
    2.0000    3.0000  -11.2867   -4.1645    2.9576    0.3565
```