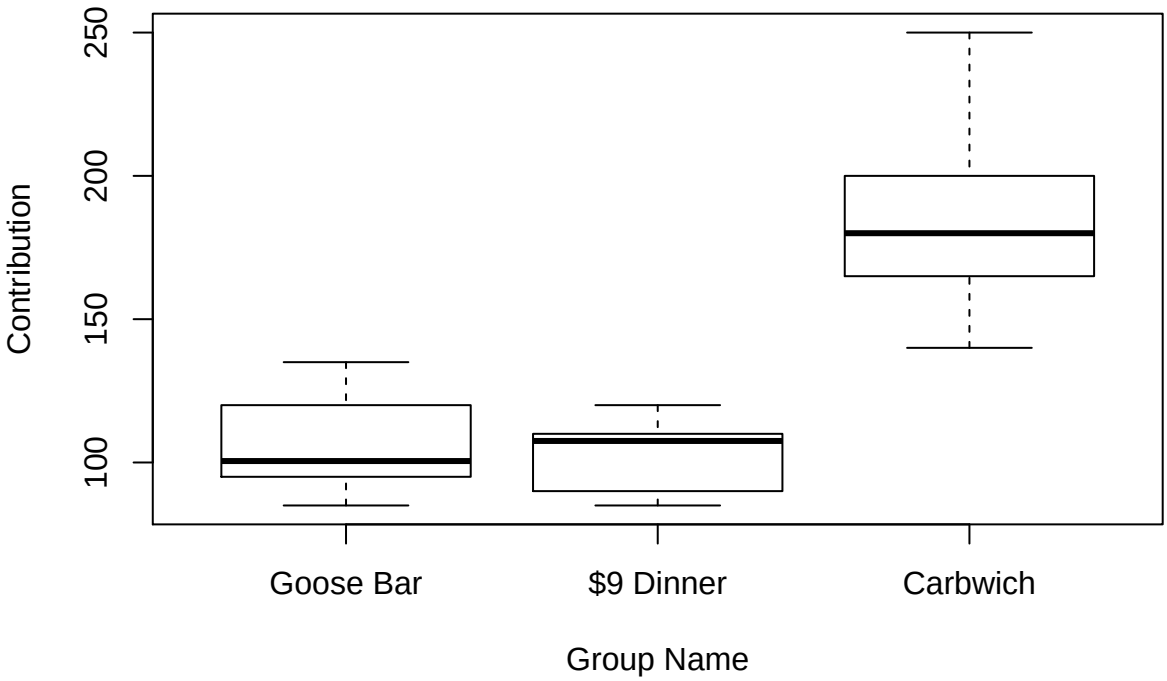
a4p1

Part a



The above graph is the boxplot of the data for all 3 groups.

code:
boxplot(t(dataQ1),xlab='Group Name',ylab='Contribution')

Part b

Based on the boxplot from part (a), the heights of boxes are a bit different, but overall we can call it seems to be similar variation in each treatment group.

Part c

```
##             Df Sum Sq Mean Sq F value   Pr(>F)
## treatments   2  42381   21191   44.14 3.09e-09 ***
## Residuals   27  12962     480
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

code:
contribution = as.numeric(t(dataQ1))
treatments = c(rep('Goose Bar',10), rep('$9 Dinner', 10),rep('Carbwich', 10))
summary(aov(contribution~treatments))

Part d

the p-value is

$$3.09 * 10^{-9}$$

code:
\begin{array}{rcl}
3.09*10^{-9}
\end{array}

Part e

$$f \quad = \quad \frac{MS_{TRT}}{MS_{RES}} \sim F_{dfTRT,dfRES}$$

the df TRT is 2 and df RES is 27 from ANOVA table in part(c) the distribution is

$$F_{2,27}$$

Part f

Since the p-value from part(d) is really small, we reject the null hypothesis that all three approaches lead to the same contribution amounts.
code:
\begin{array}{rcl}
f & = & \frac{MS_{TRT}}
{MS_{RES}}
\sim F_{dfTRT,dfRES}
\end{array}
\subsection{Part f}
\begin{array}{rcl}
F_{2,27}
\end{array}

Part g

(i) H0: tu1=tu2
p-value is :

```
## [1] 0.793
```

code:

```
mu_hat = mean(dataQ1)
tau_hat = apply(dataQ1,1,mean)
sigmasq_hat = 480
a = c(1,-1,0)
theta = sum(a * tau_hat)
se_theta = sqrt(sigmasq_hat * sum(a^2)/10)
tobs = theta / se_theta
round(2 * pt(abs(tobs), df = 27, lower.tail = FALSE),3)
```

(ii) H0:tu1=tu3
p-value is :

```
## [1] 0
```

code:

```
mu_hat = mean(dataQ1)
tau_hat = apply(dataQ1,1,mean)
sigmasq_hat = 480
a = c(1,0,-1)
theta = sum(a * tau_hat)
se_theta = sqrt(sigmasq_hat * sum(a^2)/10)
tobs = theta / se_theta
round(2 * pt(abs(tobs), df = 27, lower.tail = FALSE),3)
```

(iii) H0:tu2=tu3
p-value is :

```
## [1] 0
```

code:

```
mu_hat = mean(dataQ1)
tau_hat = apply(dataQ1,1,mean)
sigmasq_hat = 480
a = c(0,1-1)
theta = sum(a * tau_hat)
se_theta = sqrt(sigmasq_hat * sum(a^2)/10)
tobs = theta / se_theta
round(2 * pt(abs(tobs), df = 27, lower.tail = FALSE),3)
```

Part h

The null hypothesis means the average contribution from Goose bar should be equal to the 2 times of sum of the rest 2 groups.