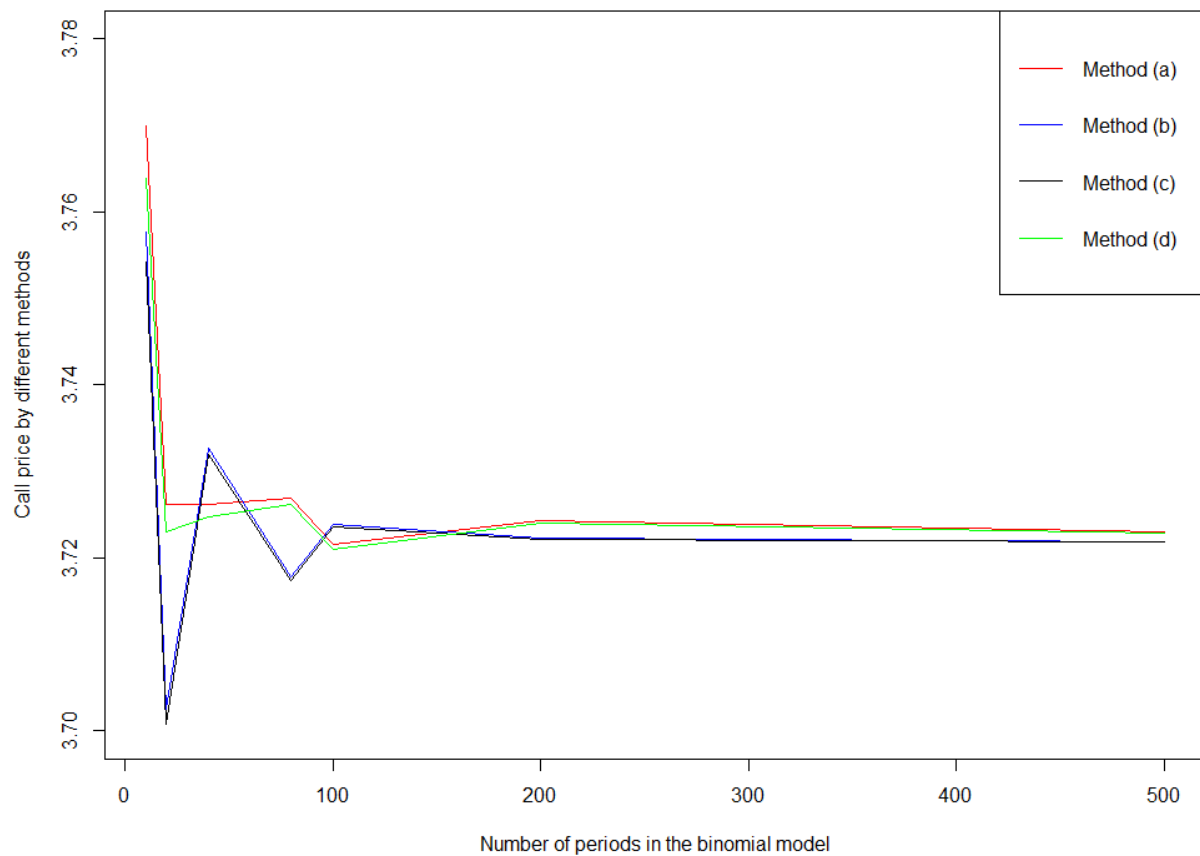


## Project 4

Nikhil Guruji

1)

The plots are attached, and convergence is observed to a value of \$3.72 as the number of periods in the binomial model is increased using all four methods.



2)

The data was read in CSV format from the Yahoo! Finance website. The volatility was calculated using the `sd()` function on the daily returns (which were calculated using the `xts` and `quantmod` packages).

It was observed that the historical annual volatility is 21.84% which resulted in an estimated call option price of \$56.63. The current stock price considered was \$1080.60 (as of February 6, 2018) and a strike price of \$1190.

The actual price on the website was \$67.51. This was different from the estimated price due to the following reasons:

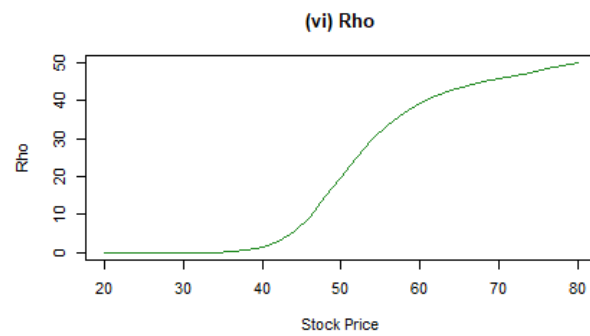
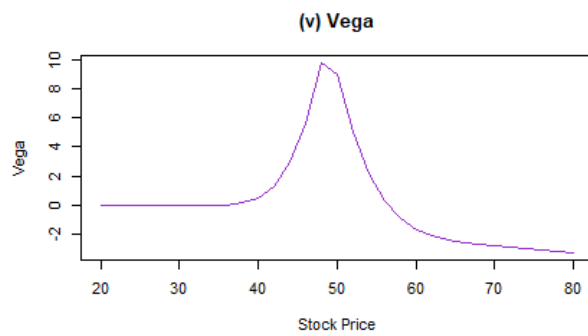
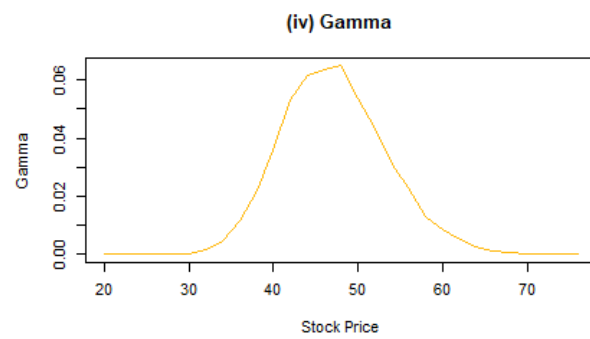
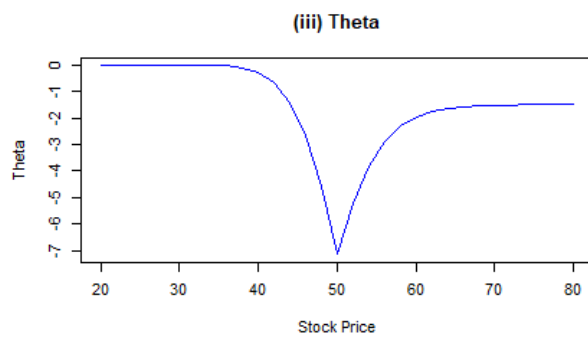
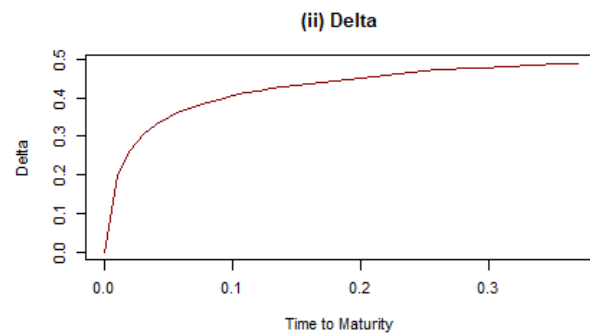
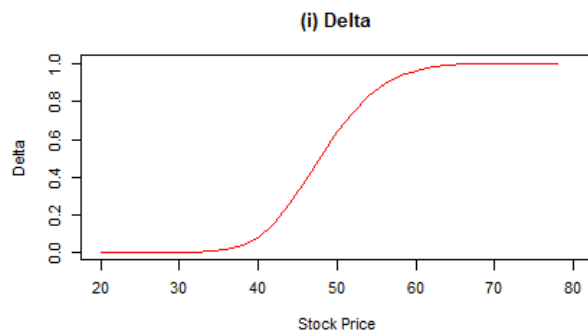
- (i) Volatility is not constant in the real world. The binomial model assumes constant volatility.
- (ii) In the real world, the stock price does not have only a fixed up or a down path. It can follow any random path which makes it hard to predict the stock price.
- (iii) Risk free rate, in the real world is not constant as assumed in the binomial option pricing model.
- (iv) The markets are not perfect. The binomial model assumes perfect markets in the sense that the same information is available for all the investors which is often not true in the real world.

The implied volatility is calculated using a guess value of volatility for which the binomial option price estimated will be close to the actual option price. This implied volatility was calculated to be 25.4%.

Implied volatility is a forward-looking measure. It can be interpreted as the volatility required for the option to have an expected payoff of \$67.51 at maturity (January 18, 2019).

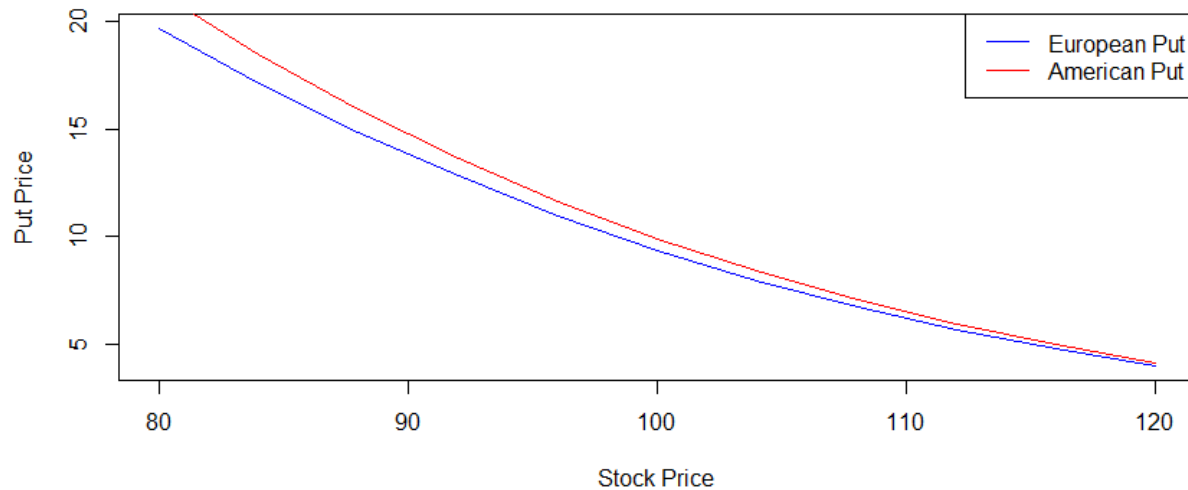
3)

The graphs are attached.



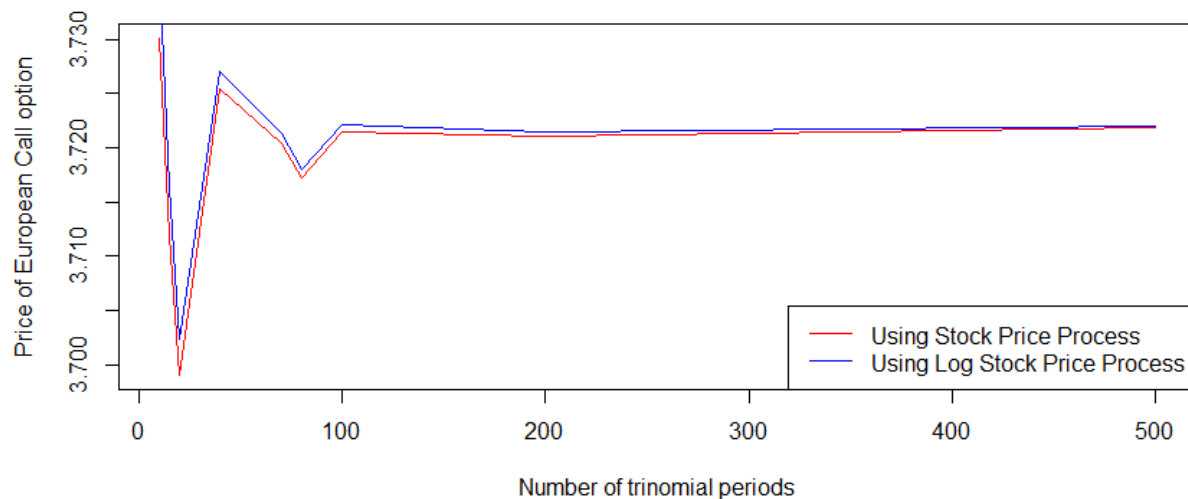
4)

As seen from the plot, the value of the American put option is more than that of the European put option with same parameters. This is because in American options, there is a choice of exercising early which gives an advantage to the option holder which, logically should increase the price of the option.



5)

The plots are attached, and convergence is observed to a value of \$3.72 as the number of periods in the binomial model is increased using both the methods.



6)

The following inputs are taken:

$$S_0 = 88$$

$$K = 100$$

$$r = 0.04$$

$$\sigma = 0.2$$

$$T = 5$$

$$\text{base}_1 = 2$$

$$\text{base}_2 = 5$$

$$n = 10000$$

The output is:

\$18.28