Project 7 by
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Q1.

a) Base case results (S=10)

```
/Users/aKumar/anaconda/bin/python /Users/aKumar/Python/com/ashwin/computationalmethodsinfinance/Project7/Q1.py
Q1.a Put Option Price for S= 10.000000, dX = 0.008944
     Price = 0.464695 [Black Scholes]
     Price = 0.466006 [Explicit Method]
     Price = 0.464875 [Implicit Method]
     Price = 0.465154 [Crank-Nicolson Method]
```

```
Q1.a Put Option Price for S= 10.000000, dX = 0.015492
     Price = 0.464695 [Black Scholes]
     Price = 0.464886 [Explicit Method]
     Price = 0.464327 [Implicit Method]
     Price = 0.464607 [Crank-Nicolson Method]
```

```
Q1.a Put Option Price for S= 10.000000, dX = 0.017889
     Price = 0.464695 [Black Scholes]
     Price = 0.464612 [Explicit Method]
     Price = 0.464052 [Implicit Method]
     Price = 0.464332 [Crank-Nicolson Method]
```

b) Comparison of the European Put Prices with Black-Scholes Prices (error deviation from BS reported). Since the stock price is generated according to X= Ln(S), I have reported the closest the stock price integral values (higher than).

dX = 0.008944

S,na	Black-Scholes, % Error	Explicit Method, % Error	Implicit Method, %Error	Crank-Nicolson Method, %Error
[4.01593163 0.]	[5.7860551 0.]	[4.96266858 -14.23053366]	[5.78527798 -0.01343086]	[5.78527011 -0.01356691]
[5.02224054 0.]	[4.77974642 0.]	[4.7354211 -0.92735709]	[4.77896926 -0.01625929]	[4.77896131 -0.01642563]
[6.00601576 0.]	[3.79604411 0.]	[3.79423261 -0.04772093]	[3.79527826 -0.02017512]	[3.79526315 -0.02057318]
[7.05515453 0.]	[2.75082332 0.]	[2.74998598 -0.03043962]	[2.75022557 -0.02172983]	[2.75012738 -0.02529937]
[8.06813673 0.]	[1.78232248 0.]	[1.78200562 -0.01777806]	[1.78214839 -0.00976755]	[1.78197576 -0.0194533]
[9.06298107 0.]	[0.98069887 0.]	[0.98045814 -0.02454613]	[0.98078596 0.00888028]	[0.98085842 0.01626946]
[10. 0.]	[0.46469453 0.]	[0.46600565 0.28214466]	[0.46487486 0.03880535]	[0.46515394 0.09886143]
[11.03389704 0.]	[0.16527016 0.]	[0.16545791 0.11360301]	[0.16558579 0.19097748]	[0.16573599 0.28186311]
[12.06628021 0.]	[0.04820688 0.]	[0.04824965 0.08871678]	[0.04854244 0.69606607]	[0.04850424 0.61683331]
[13.07776226 0.]	[0.01222138 0.]	[0.01236505 1.17557725]	[0.01244437 1.82458596]	[0.01236325 1.160841]
[14.04782284 0.]	[0.00288672 0.]	[0.00291917 1.12411495]	[2.99893344e-03 3.88714300e+00]	[0.00294572 2.04367173]
[15.08983896 0.]	[0.00054766 0.]	[5.73092723e-04 4.64303345e+00]	[6.15657385e-04 1.24150661e+01]	[5.91186660e-04 7.94686962e+00]
[16.06481544 0.]	[0.00010629 0.]	[2.41280527e-04 1.27003837e+02]	[0. -100.]	[2.57474768e-04 1.42239857e+02]

dX = 0.015492

S,na	Black-Scholes, % Error	Explicit Method, % Error	Implicit Method, %Error	Crank-Nicolson Method, %Error
[4.00907693 0.]	[5.7929098 0.]	[4.99873814 -13.70937381]	[5.79213097 -0.01344449]	[5.7921231 -0.01358038]
[5.05784258 0.]	[4.74414444 0.]	[4.70811117 -0.75953155]	[4.74336534 -0.01642237]	[4.74335736 -0.01659052]
[6.09118854 0.]	[3.71090682 0.]	[3.7094691 -0.03874293]	[3.71014789 -0.02045132]	[3.71013032 -0.02092475]
[7.00252379 0.]	[2.8028601 0.]	[2.80208621 -0.02761057]	[2.80228037 -0.02068331]	[2.80218942 -0.02392812]
[8.05020877 0.]	[1.79855644 0.]	[1.7980126 -0.03023786]	[1.79836108 -0.01086235]	[1.79818698 -0.02054251]
[9.11237603 0.]	[0.94717027 0.]	[0.94707498 -0.01006057]	[0.94689685 -0.02886708]	[0.94698566 -0.01949053]
[10. 0.]	[0.46469453 0.]	[0.46488609 0.041221]	[0.46432663 -0.07917158]	[0.46460657 -0.01892897]
[11.14541973 0.]	[0.14600163 0.]	[0.14624217 0.16474568]	[0.14599118 -0.00716334]	[0.14611638 0.07859127]
[12.04305679 0.]	[0.04966021 0.]	[0.04981238 0.30641545]	[0.04988421 0.45105702]	[0.04984809 0.37833455]
[13.01298832 0.]	[0.01340194 0.]	[0.01346897 0.5001449]	[0.01363249 1.72029664]	[0.01355092 1.11159534]
[14.06103684 0.]	[0.00282842 0.]	[0.00285189 0.82988723]	[2.95711586e-03 4.55011449e+00]	[0.00290467 2.69590649]
[15.19349376 0.]	[0.00046169 0.]	[4.92382152e-04 6.64795026e+00]	[5.37021357e-04 1.63166185e+01]	[5.14674256e-04 1.14763283e+01]
[16.16478366 0.]	[8.94931284e-05 0.00000000e+00]	[2.33441807e-04 1.60848868e+02]	[0. -100.]	[2.49251474e-04 1.78514657e+02]

dX = 0.017889

S,na	Black-Scholes, % Error	Explicit Method, % Error	Implicit Method, %Error	Crank-Nicolson Method, %Error
[4.01593163 0.]	[5.7860551 0.]	[5.0005572 -13.5757072]	[5.78527542 -0.01347527]	[5.78526754 -0.01361132]
[5.06736231 0.]	[4.73462473 0.]	[4.69933578 -0.74533778]	[4.73384465 -0.01647602]	[4.73383666 -0.01664472]
[6.05997616 0.]	[3.7421047 0.]	[3.74055608 -0.04138355]	[3.74134496 -0.02030257]	[3.74132827 -0.02074836]
[7.1185408 0.]	[2.68826918 0.]	[2.68753069 -0.02747089]	[2.68775116 -0.01926985]	[2.68764494 -0.02322118]
[8.06813673 0.]	[1.78232248 0.]	[1.78177618 -0.03065082]	[1.78212248 -0.01122132]	[1.78194945 -0.02092904]
[9.14440644 0.]	[0.92579357 0.]	[0.92552266 -0.02926314]	[0.92532336 -0.0507903]	[0.92542277 -0.04005219]
[10. 0.]	[0.46469453 0.]	[0.46461221 -0.01771596]	[0.46405188 -0.13829649]	[0.46433226 -0.07795955]
[11.13302989 0.]	[0.1480432 0.]	[0.14811412 0.04790356]	[0.14785804 -0.12507506]	[0.14798579 -0.03878132]
[12.1746884 0.]	[0.04191807 0.]	[0.04201158 0.22306263]	[0.04211166 0.46182861]	[0.04206148 0.34211591]
[13.07776226 0.]	[0.01222138 0.]	[0.01228565 0.52593869]	[0.01244792 1.85365665]	[0.01236698 1.19142014]
[14.04782284 0.]	[0.00288672 0.]	[0.00291957 1.13774458]	[3.02540971e-03 4.00431718e+00]	[2.97265691e-03 2.97688818e+00]
[15.08983896 0.]	[0.00054766 0.]	[5.78247087e-04 5.58418711e+00]	[6.26058296e-04 1.43142054e+01]	[6.02139279e-04 9.94674714e+00]
[16.20914803 0.]	[8.28985764e-05 0.00000000e+00]	[2.29286673e-04 1.76586985e+02]	[0. -100.]	[2.44705044e-04 1.95186063e+02]

```
Process finished with exit code 0
```

Based on the comparisons, we can see that, CNF & Implicit methods has better stability. We can also infer CNF method has faster convergence, (though it is not evident at looking at small set of patterns).

Explicit method has a good bound of error from the BS Option price. The plot below shows the rate of convergence.

Fig a

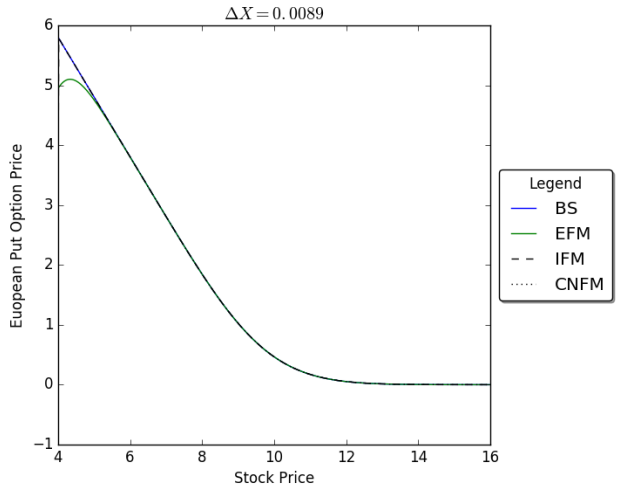


Fig b

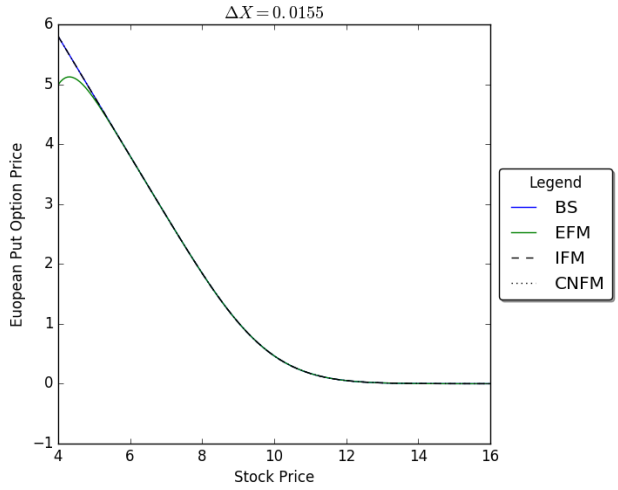
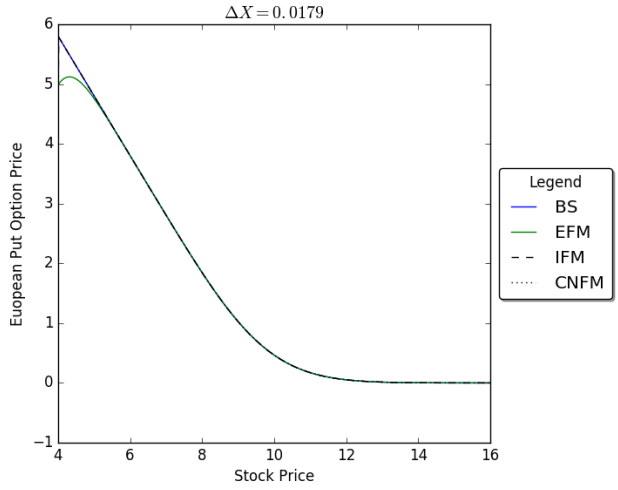


Fig c



Q2. a)

```
/Users/akumar/anaconda/bin/python /Users/akumar/Python/com/ashwin/comput
Q2.a American Put Option Price for S= 10.000000, dX = 0.500000
     Price = 0.474163 [Explicit Method]
     Price = 0.473290 [Implicit Method]
     Price = 0.473725 [Crank-Nicolson Method]
Q2.a American Call Option Price for S= 10.000000, dX = 0.500000
     Price = 0.655479 [Explicit Method]
     Price = 0.654425 [Implicit Method]
     Price = 0.654811 [Crank-Nicolson Method]
Q2.a American Put Option Price for S= 10.000000, dX = 1.000000
     Price = 0.440889 [Explicit Method]
     Price = 0.439993 [Implicit Method]
     Price = 0.440441 [Crank-Nicolson Method]
Q2.a American Call Option Price for S= 10.000000, dX = 1.000000
     Price = 0.624288 [Explicit Method]
     Price = 0.621310 [Implicit Method]
     Price = 0.622541 [Crank-Nicolson Method]
Q2.a American Put Option Price for S= 10.000000, dX = 1.500000
     Price = 0.415019 [Explicit Method]
     Price = 0.414127 [Implicit Method]
     Price = 0.414572 [Crank-Nicolson Method]
Q2.a American Call Option Price for S= 10.000000, dX = 1.500000
     Price = 0.602931 [Explicit Method]
     Price = 0.593367 [Implicit Method]
     Price = 0.594987 [Crank-Nicolson Method]
```