Homework 2. Group 3.

Deadline: January 14, 23:59

- Files should be submitted in Jupiter-readable format .ipynb.
- All cells should not produce any errors.
- Code should be clear, important comments are necessary. Clarity and transparency will be assessed, not only correct answers.
- Answer should be visible. It means that when grader executes cell he should see answer clearly as cell output.

Problem 1 [50 pts]

1.1) Write base class *figure* with methods *area*(), *perimeter*() and *center_distance*(x,y). What first two methods do is clear. The last method center_distance(x,y) calculates distance from center of the figure to point with coordinates (x,y).
Constructor of figure class takes two values (x0, y0) – center of figure. Decide which methods implementations should be left empty and which could be implemented on base class.
Outputs:
- Create object of *figure* class with center coordinates (1,0)
- Output values x0 and y0

1.2) Write child class *rectangular* and implement methods from base class.
Outputs:
- Create object of *rectangular* class with center coordinates (2,3) and sides 3 and 5.
- Output methods *area*(), *perimeter*() and *center_distance*(10,10).

1.3) Write child class *circle* and implement methods from base class.
Outputs:
- Create object of *circle* class with center coordinates (5,5) and radius 4.
- Output methods *area*(), *perimeter*() and *center_distance*(10,10).

Problem 2 [50 pts] Pricing Forward in **Binomial model**.

- Consider Binomial model for evolution of stock price after n days $S_n = S_0 X_1 X_2 \dots . X_n$, where $X_1, \dots ., X_n$ are iid random variables with distribution

X	1+u	1+d
P	p	$1-p$

$p = \frac{\tilde{r}-d}{u-d}$, where $\tilde{r}$ is risk-free interest rate earned for a day. Assume continuously accrued interest rate i.e. money grow via $B_t = B_0 e^{rt}$, $r -$ yearly interest rate.

- Consider forward contract with payoff $f(S_T) = S_T - K$ (T −maturity, K −strike). Fair price of forward can be computer via

$$PV = E\left(\frac{S_T - K}{e^{rT}}\right)$$

Parameters for our task: $S_0 = 100,\ u = 0.01, d = -0.006, r = 7\ \%\ (yearly)$,

For forward contract: $K = 110, T = 3\ months$.

Tasks:

1) Design and create class *forward*.
   Output: payoff on given data
2) Design generic class pricer and two derived classes analytic_pricer and mc_pricer.
   Outputs:
   - price of given forward via Monte-Carlo method. Price via Monte-Carlo is sample mean of discounted payoffs
   - analytic price of forward. Use the formula

$$PV = S_0 - \frac{K}{e^{rT}}$$

+10 points to the course: in separate markdown cell derive PV formula i.e. prove

$$E\left(\frac{S_T - K}{e^{rT}}\right) = S_0 - \frac{K}{e^{rT}}$$