Problem Statement

Let's assume there is a financial contract ABC, which you can buy or sell today or the dealing date (t_{deal}) at a value V_{deal}. One unit of this pays its holder, final redemption payment F (usually 100 INR) at the final date when the contract expires. It also pays a periodic income cf at the end of each period based on a provided constant rate C (in percentage), F and the respective length of each period from the start of the contract up until the final date.

Thus to describe a unique ABC product we need the following details:

(1) Start Date (t_{start})

(2) Final Date (t_{final})

(3) Periodic frequency ($freq$)

(4) Periodic roll day (prd)

(5) Final Redemption payment (F)

(6) Constant rate C.

Periodic frequency defines after how many months will the periodic income happen, and prd defines which day of the month is used for this cash flow (if such a day doesn't exist in that month then assume it to be the last day of that month). If the final date doesn't fall on the regular periodic schedule from the start date, then assume a short stub period at the end.

For example, let's say there is a ABC contract with:

t_{start} = "1Jan2022", t_{final} = "1Jan2024", $freq$ = "12m", prd = 1, F = 100, C = 3

Then this contract will pay periodic payment on 1Jan2023 and 1Jan2024, along with final redemption payment of 100 on 1Jan2024.

Thus first period is from 1Jan2022 to 1Jan2023 and the final period is from 1Jan2023 to 1Jan2024. If prd = 13 in this earlier case, then it will make periodic payment on 13Jan2023 and 1Jan2024, along with final redemption payment of 100 on 1Jan2024. Thus first period is from 1Jan2022 to 13Jan2023 and the final period is from 13Jan2023 to 1Jan2024. If you need to assume some edge cases, please do so and clearly describe that in the explanation document.

Let's define r_{deal} to be the rate of return, if one buys ABC at the dealing date at the value V_{deal} and hold it till its final date, thus receiving all the remaining periodic income and the final flow, along with the assumption that all the intermediate income is reinvested with the same rate of return.

So, periodic income for the i^{th} period is $cf_i = C * \tau_i * F * 0.01$ and $\tau_i = \tau(t_{period\_start\_i}, t_{period\_end\_i})$, where τ is the measure of time in years evaluated by number of days between start data and the end date divided by 365.

And the relationship between V_{deal} and r_{deal} is given as below,

$$V_{deal} = \frac{F + \mu_N}{1 + r_{deal} * \tau(t_{deal}, t_{final}) * 0.01}$$

$$\mu_0 = 0,$$

$$\mu_i = (cf_i + \mu_{i-1})(1 + r_{deal*} \tau(t_{\max(deal, period\_start\_i)}, t_{period\_end\_i}) * 0.01)$$

Here N is the number of remaining periodic flows from the dealing date to the final date (τ_N *is assumed to be* 0).

You are expected to create a python class for the financial product ABC, using its attributes like t_{start}, t_{final}, $freq$, prd, F and C. You can design the class and other member functions as you see fit, at the least it should have a constructor which takes in the given ABC attributes and have some given member functions. The calculation of rate of return or the value or the risks functionalities should be captured using ABC class member functions along with other parameters.

Submission Format

Three files are expected from you put together in a .zip file, for it to be qualified as a valid submission. See details for the files and their extensions. Please ensure that these files are actually zipped directly, and not any folder which contain these files.

1. Python code in a file with .py extension

This file should contain a ABC class and four public member function value_abc, rateofreturn_abc, dvalue_drateofreturn_abc and d2value_ drateofreturn2_abc. See details below

a) Write a class C_ABC which can be constructed using the details of the financial product ABC.
   class C_ABC:
   …

   o_abc = C_ABC($\boldsymbol{t_{start}}$, $\boldsymbol{t_{final}}$, $\boldsymbol{freq}$, $\boldsymbol{prd}$, $\boldsymbol{F}$, $\boldsymbol{C}$**)**

here

$\boldsymbol{t_{start}}$ is the start date of the first period of the contract ABC in a string DDMmmYYYY format (e.g. “12Aug2022”)

$\boldsymbol{t_{final}}$ is the end date of the final period of the contract ABC in a string DDMmmYYYY format (e.g. “12Aug2025”)

$\boldsymbol{freq}$ is the gap in months for each period in months in string format, possible values are "1m", "2m", "3m", "6m" and "12m".

$\boldsymbol{prd}$ is a positive integer, possible values 1-31

F is the final redemption payment in decimal number (e.g. 100)

$\boldsymbol{C}$ is the periodic payment rate in decimal number (e.g. pass 2.4 for 2.4%)

b) You are expected to write a member function of class ABC which returns V_{deal} given other parameters. The interface of the function should be as below

def value_abc(t_{deal},r_{deal}**)**:

…

return V_{deal}

Here $\boldsymbol{t_{deal}}$ is the dealing date in a string DDMmmYYYY format (e.g. "12Aug2022")

$\boldsymbol{r_{deal}}$ is the rate of return in decimal number (e.g. pass 1.5 for 1.5%)

c) You are expected to write a member function of class ABC which returns r_{deal} given other parameters. The interface of the function should be as below

def rateofreturn_abc(t_{deal},V_{deal}**)**:

…

return r_{deal}

Here $\boldsymbol{t_{deal}}$ is the dealing date in a string DDMmmYYYY format (e.g. "12Aug2022")

$\boldsymbol{V_{deal}}$ is the value of ABC on the dealing date in decimal number (e.g. 97.93)

d) You are expected to write a member function dvalue_drateofreturn_abc which returns $\boldsymbol{dV_{deal}/dr_{deal}}$ given other parameters. dV_{deal}/dr_{deal}, is the first differential of the ABC value V_{deal} on the dealing date with respect to the rate of return r_{deal} on the dealing date. You are expected to implement an analytical formula for this differentiation (**NO** bump and revalue, and the whole question would be disqualified if bump and revalue is used here in any form).

def dvalue_drateofreturn_abc(t_{deal},r_{deal}**)**:

…

return dV_{deal}/dr_{deal}

Hint: Use chain rule.

e) You are expected to write a member function d2value_ drateofreturn2_abc which returns $\boldsymbol{d^2V_{deal}/dr_{deal}}^{\boldsymbol{2}}$ given other parameters. $d^2V_{deal}/dr_{deal}{}^2$, is the second differential of the ABC value V_{deal} on the dealing date with respect to the rate of return r_{deal} on the dealing date. You are expected to implement an analytical formula for this differentiation (**NO** bump and revalue, and the whole submission for this question would be disqualified if bump and revalue is used here in any form).

def d2value_ drateofreturn2_abc(t_{deal},r_{deal}**)**:

…

return $d^2V_{deal}/dr_{deal}{}^2$

Hint: Use chain rule.

The file should be named as Q3.py

2. A windows doc (extension .docx) file explaining your algorithm

Write a one-two pager document briefly explaining the steps in your algorithm, and or any other feature/coding practice you would like to highlight.

The doc file should be named as Q3_explanation.docx

3. A .csv file with test outputs from the function

Write the output result of the following sample inputs in TBD format.

For the object o_abc = C_ABC("03Feb2022", "03Feb2024", "3m", 3, 100, 4)

(1) Function = o_abc.value_abc, t_{deal} = "15Mar2023", r_{deal} = 1.1
(2) Function = o_abc.rateofreturn_abc, t_{deal} = "15Mar2023", V_{deal} = 115.1
(3) Function = o_abc.dvalue_drateofreturn_abc, t_{deal} = "27Apr2023", r_{deal} = 2.37
(4) Function = o_abc.d2value_ drateofreturn2_abc, t_{deal} = "07Jan2023", r_{deal} = 5.3

You need to input your results in the SampleSubmission.csv and saved that as Q3.csv.

You shall submit the following files as a zip file for this submission:

- Q3_Explanation.docx
- Q3.py.
- The updated csv which was provided with this problem with your predictions in the format mentioned below as Q3.csv. The file will contain results for the four problems in the first column.

-99
-24
0.2
1003.5

Put the files in a zip and upload the zip file. Do note that you need not put the files in a folder when zipping.

Evaluation Criteria

We shall measure submissions on the criteria:

$\Sigma\ \{all\ \text{problems}\}\ (PredictedS\text{olution} - ActualS\text{olution})^2$

Primarily we shall use the prediction file provided for test to form a cutoff.

We shall use extra out-of-sample inputs not provided to you for final scoring.