



# مبانی مهندسی سیستم Principles of System Engineering

موضوع جلسه:

## مدل سازی جریان نقدینگی Cash Flow Modelling

Semester: 14011

University of Science and Technology of Mazandaran (USTM)

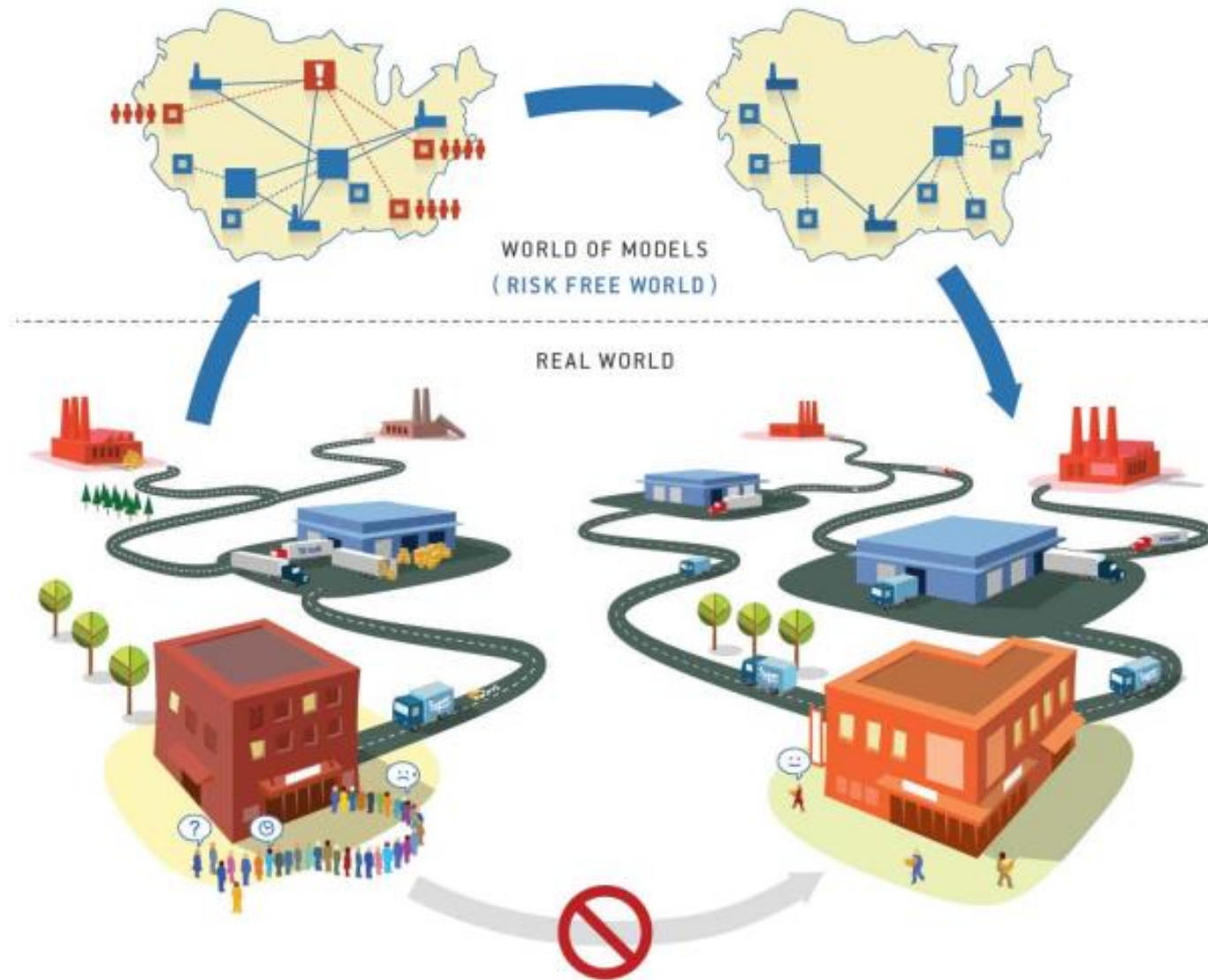
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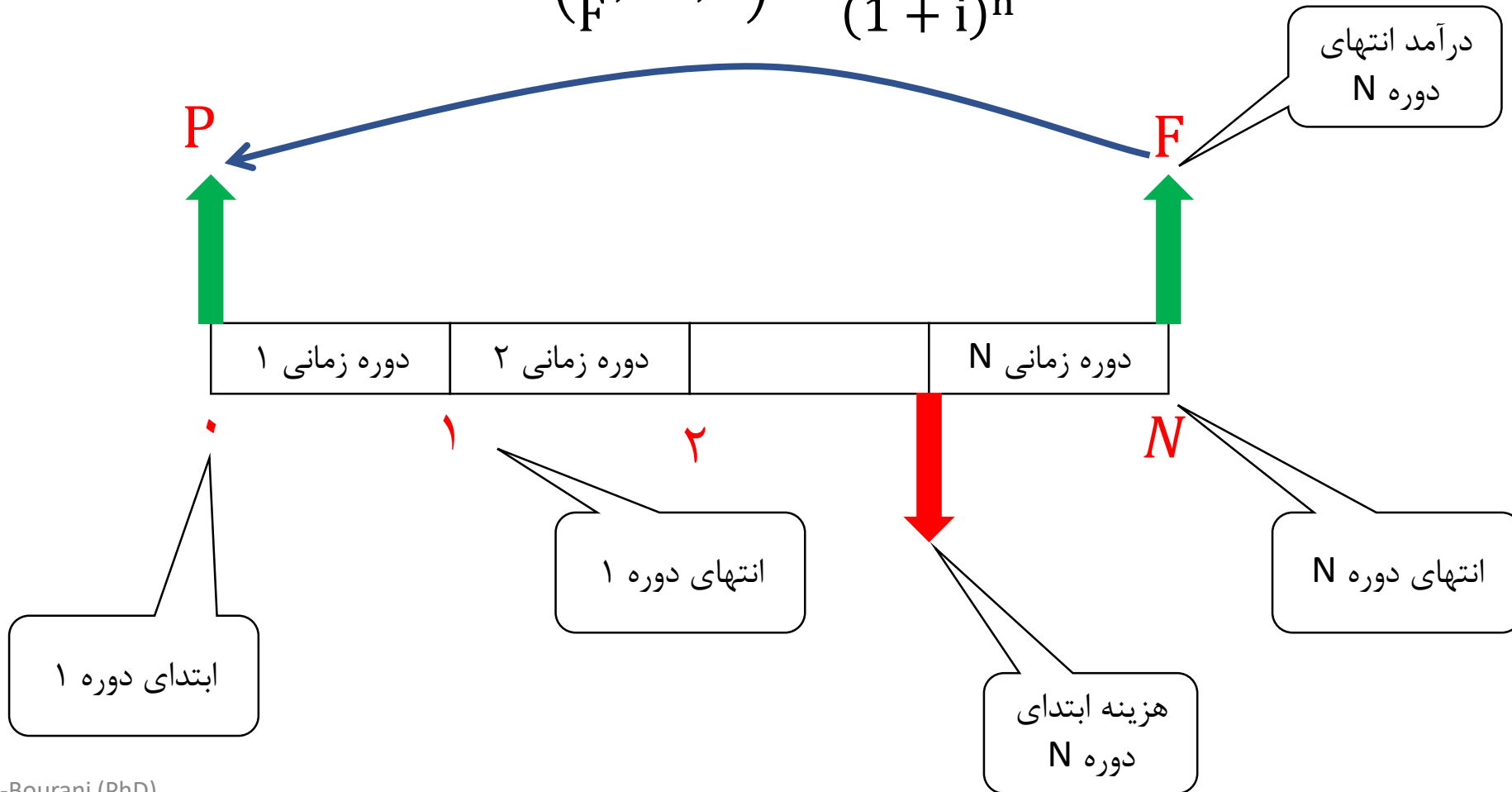
- فرآیند مدل‌سازی: دنیای واقعی و دنیای بدون ریسک مدل
- عناصر اصلی جریان نقدینگی (Cash Flow)
- محاسبه شاخص ارزش خالص فعلی (Net Present Value)
- مدل‌سازی جریان نقدینگی در نرم افزار اکسل
  - (۱) جریان نقدینگی یکنواخت (Cash Flow Uniform)
  - (۲) جریان نقدینگی پله‌ای (Cash Flow Step)
  - (۳) جریان نقدینگی شیب‌دار (Cash Flow Gradient)
  - (۴) جریان نقدینگی پله‌ای یکنواخت (Cash Flow Step Uniform)
  - (۵) جریان نقدینگی شیب‌دار یکنواخت (Cash Flow Gradient Uniform)

# مدل سازی اقتصادی برای ارزیابی عملکرد اقتصادی سیستم‌ها



# عناصر اصلی جریان نقدینگی (Cash Flow)

$$P = F \times \left( \frac{p}{F}, i\%, n \right) = \frac{F}{(1 + i)^n}$$



$$NPV = \sum_{n=0}^{NP} \frac{NV_n}{(1+i)^n}$$

$$= \sum_{n=0}^{NP} \frac{TR_n - TC_n}{(1+i)^n}$$

*NPV*: Net Present Value

*NP*: Number of periods

*NV<sub>n</sub>*: Net Value at the end of period *n*

*i*: Discount Rate

*TR<sub>n</sub>*: Total Revenue at the End of Period *n*

*TC<sub>n</sub>*: Total Cost at the End of Period *n*

# فرضیات کلی مدل اقتصادی و تعریف پارامترها

| Type    | No. | Description                             | Parameter | Value | Unit           |
|---------|-----|---|-----------|-------|----------------|
| General | 1   | Minimum Attractive Rate of Return Year  | MARRY     | 15%   | NA             |
|         | 2   | Minimum Attractive Rate of Return Month | MARRM     | 1.25% | NA             |
|         | 3   | Number of Periods                       | NP        | 24    | Month          |
|         | 4   | Capital Expenditure                     | Capex     | 3000  | Million Tomans |





Name Manager ? X

| Name  | Value | Refers To     | Scope    | Comment |
|-------|-------|---------------|----------|---------|
| Capex | 3000  | =Input!\$E\$5 | Workbook | General |
| MARRM | 1.25% | =Input!\$E\$3 | Workbook | General |
| MARRY | 15%   | =Input!\$E\$2 | Workbook | General |
| NP    | 24    | =Input!\$E\$4 | Workbook | General |

- ۱) جریان نقدینگی یکنواخت (Cash Flow Uniform)
- ۲) جریان نقدینگی پله ای (Cash Flow Step)
- ۳) جریان نقدینگی شیب دار (Cash Flow Gradient)
- ۴) جریان نقدینگی پله ای یکنواخت (Cash Flow Step Uniform)
- ۵) جریان نقدینگی شیب دار یکنواخت (Cash Flow Gradient Uniform)

# ۱) جریان نقدینگی یکنواخت (Cash Flow Uniform): پارامتر و مدل

| Type    | No. | Description                      | Parameter | Value | Unit           |
|---------|-----|----------------------------------|-----------|-------|----------------|
| Uniform | 1   | Start Time of Cash Flow Uniform  | STCFU     | 2     | Month          |
|         | 2   | End Time of Cash Flow Uniform    | ETCFU     | 24    | Month          |
|         | 3   | Frequency of Cash Flow Uniform   | FQCFU     | 2     | Month          |
|         | 4   | First Value of Cash Flow Uniform | FVCFU     | 750   | Million Tomans |

| Name  | Value | Refers To     | Scope    | Comment |
|---|-------|---------------|----------|---------|
|  ETCFU   | 24    | =Input!\$E\$7 | Workbook | Uniform |
|  FQCFU  | 2     | =Input!\$E\$8 | Workbook | Uniform |
|  FVCFU | 750   | =Input!\$E\$9 | Workbook | Uniform |
|  STCFU | 2     | =Input!\$E\$6 | Workbook | Uniform |

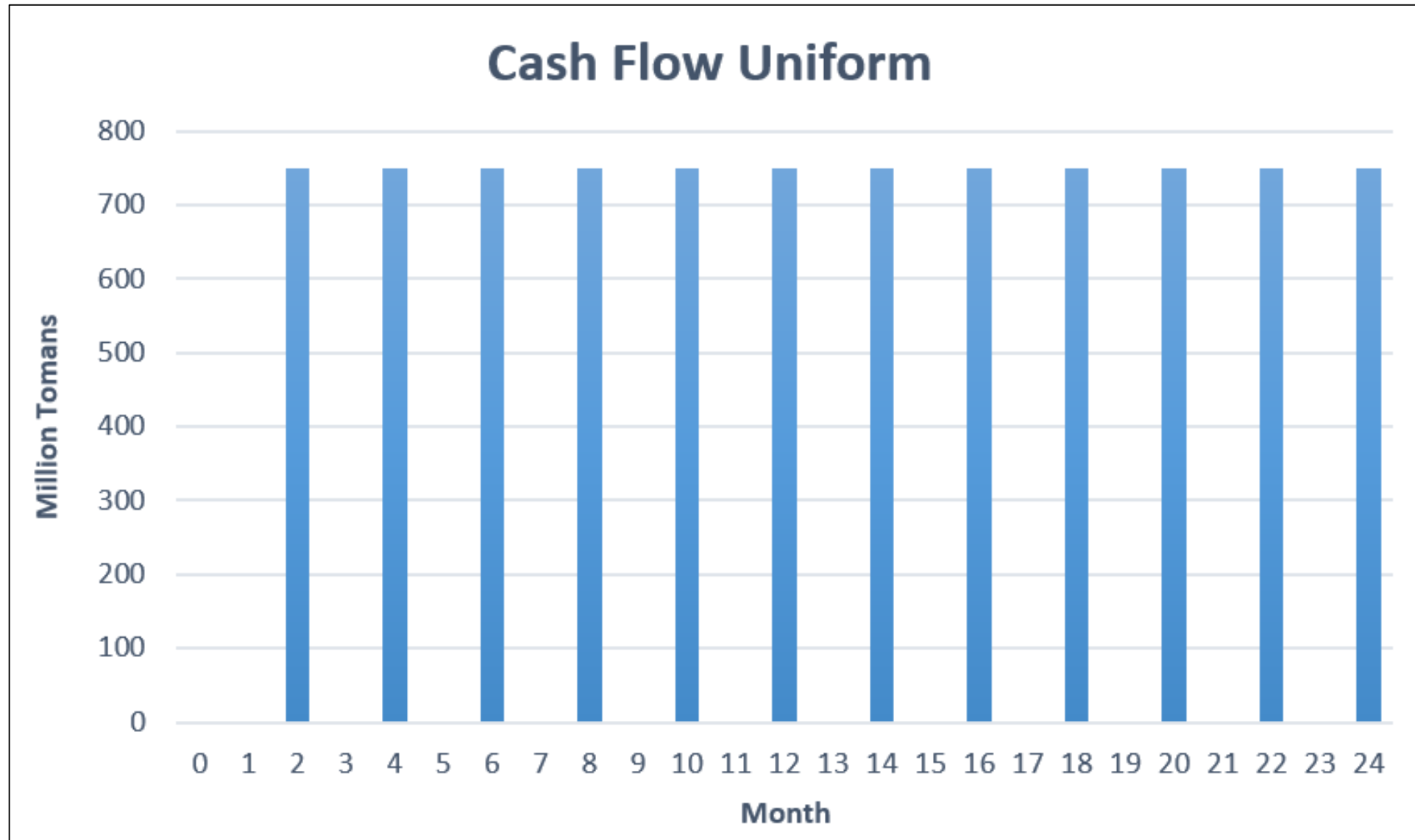


# ۱) جریان نقدینگی یکنواخت (Cash Flow Uniform): پارامتر و مدل

| Type    | No. | Description                      | Parameter | Value | Unit           |
|---------|-----|----------------------------------|-----------|-------|----------------|
| Uniform | 1   | Start Time of Cash Flow Uniform  | STCFU     | 2     | Month          |
|         | 2   | End Time of Cash Flow Uniform    | ETCFU     | 24    | Month          |
|         | 3   | Frequency of Cash Flow Uniform   | FQCFU     | 2     | Month          |
|         | 4   | First Value of Cash Flow Uniform | FVCFU     | 750   | Million Tomans |

|   | C                 | D              | E       | F    | G    | H    | I    | J    | K    |
|---|-------------------|----------------|---------|------|------|------|------|------|------|
| 1 | Month             | Unit           | 0       | 1    | 2    | 3    | 4    | 5    | 6    |
| 2 | Capex             | Million Tomans | 3000    | 0    | 0    | 0    | 0    | 0    | 0    |
| 3 | Cash Flow Uniform | Million Tomans | 0       | 0    | 750  | 0    | 750  | 0    | 750  |
| 4 | P/F               | Number         | 1.00    | 0.99 | 0.98 | 0.96 | 0.95 | 0.94 | 0.93 |
| 5 | Net Value         | Million Tomans | -3000   | 0    | 750  | 0    | 750  | 0    | 750  |
| 6 | NPV               | Million Tomans | 4686.05 |      |      |      |      |      |      |

# ۱) جریان نقدینگی یکنواخت (Cash Flow Uniform): نمودار



=IF(logical\_test, [value\_if\_true], [value\_if\_false])

Checks whether a condition is met, and returns one value if TRUE, and another value if FALSE

مثال

|    | A  | B    | C     | D     | E      |
|----|--|------|-------|-------|--------|
| 7  | <b>IF</b>                                  |      |       |       |        |
| 8  | Logical Test                               | TRUE | FALSE | Input | Result |
| 9  | If Input=A, Result=500<br>Else Result=1000 | 500  | 1000  | A     | 500    |
| 10 | If Input=A, Result=500<br>Else Result=1000 | 500  | 1000  | B     | 1000   |

=IF(D9="A",B9,C9)

=IF(D10="A",B10,C10)

=IF(logical\_test, [value\_if\_true], [value\_if\_false])

Checks whether all arguments are TRUE, and returns TRUE if all arguments are TRUE.

مثال

|    | A   | B       | C       | D      |
|----|---|---------|---------|--------|
| 12 | <b>AND</b>  | Input 1 | Input 2 | Result |
| 13 | If both values are one, result is TRUE else the result is FALSE | 0       | 0       | FALSE  |
| 14 |   | 1       | 0       | FALSE  |
| 15 |   | 0       | 1       | FALSE  |
| 16 |   | 1       | 1       | TRUE   |

=AND(B13=1,C13=1)

=MOD(Number , Divisor)

مثال

Returns the remainder after a number is divided by a divisor

| Number | Divisor | Function  | Result |
|--------|---------|-----------|--------|
| 7      | 4       | MOD(7,4)  | 3      |
| 20     | 3       | MOD(20,3) | 2      |
| 12     | 3       | MOD(12,3) | 0      |

**=OFFSET(reference, rows, cols, [height], [width])**

Returns a reference to a range that is a given number of rows and columns from a given reference.

مثال

|    | A             | B       | C       | D       |
|----|---------------|---------|---------|---------|
| 18 | <b>OFFSET</b> | Month 1 | Month 2 | Month 3 |
| 19 |               | 100     | 200     | 300     |
| 20 |               | 100     | 200     | 300     |

**{=OFFSET(B19,0,0,1,3)}**

**Ctrl+Shirft+Enter**

# 1) جریان نقدینگی یکنواخت (Cash Flow Uniform): فرمول

|   | A                 | C       |
|---|-------------------|---------|
| 1 | Month             | 0       |
| 2 | Capex             | 3000    |
| 3 | Cash Flow Uniform | 0       |
| 4 | P/F               | 1.00    |
| 5 | Net Value         | -3000   |
| 6 | NPV               | 4686.05 |

$=IF(C1>NP,"",IF(C1=0,Capex,0))$

$=IF(C1>NP,"",IF(C\$1<STCFU,0,IF(C\$1>ETCFU,0,IF(MOD(C\$1-STCFU,FQCFU)=0,FVCFU,0))))$

$=IF(C1>NP,"",1/(1+MARRM)^{C1})$

$=IF(C1>NP,"",C3-C2)$

$=SUMPRODUCT(OFFSET(\$C4,0,0,1,NP+1),OFFSET(\$C5,0,0,1,NP+1))$

## (۲) جریان نقدینگی پله‌ای (Cash Flow Step)

| Type | No. | Description                  | Parameter | Value | Unit           |
|------|-----|------------------------------|-----------|-------|----------------|
| Step | 1   | Start Time of Cash Flow Step | STCFS     | 2     | Month          |
|      | 2   | End Time of Cash Flow Step   | ETCFS     | 22    | Month          |
|      | 3   | Frequency of Cash Flow Step  | FQCFS     | 2     | Month          |
|      | 4   | First Value of Step          | FVS       | 400   | Million Tomans |
|      | 5   | Cash Flow Step               | CFS       | 300   | Million Tomans |

| Name    | Value | Refers To      | Scope    | Comment |
|---------|-------|----------------|----------|---------|
| ☰ STCFS | 2     | =Input!\$E\$10 | Workbook | Step    |
| ☰ FVS   | 400   | =Input!\$E\$13 | Workbook | Step    |
| ☰ FQCFS | 2     | =Input!\$E\$12 | Workbook | Step    |
| ☰ ETCFS | 22    | =Input!\$E\$11 | Workbook | Step    |
| ☰ CFS   | 300   | =Input!\$E\$14 | Workbook | Step    |

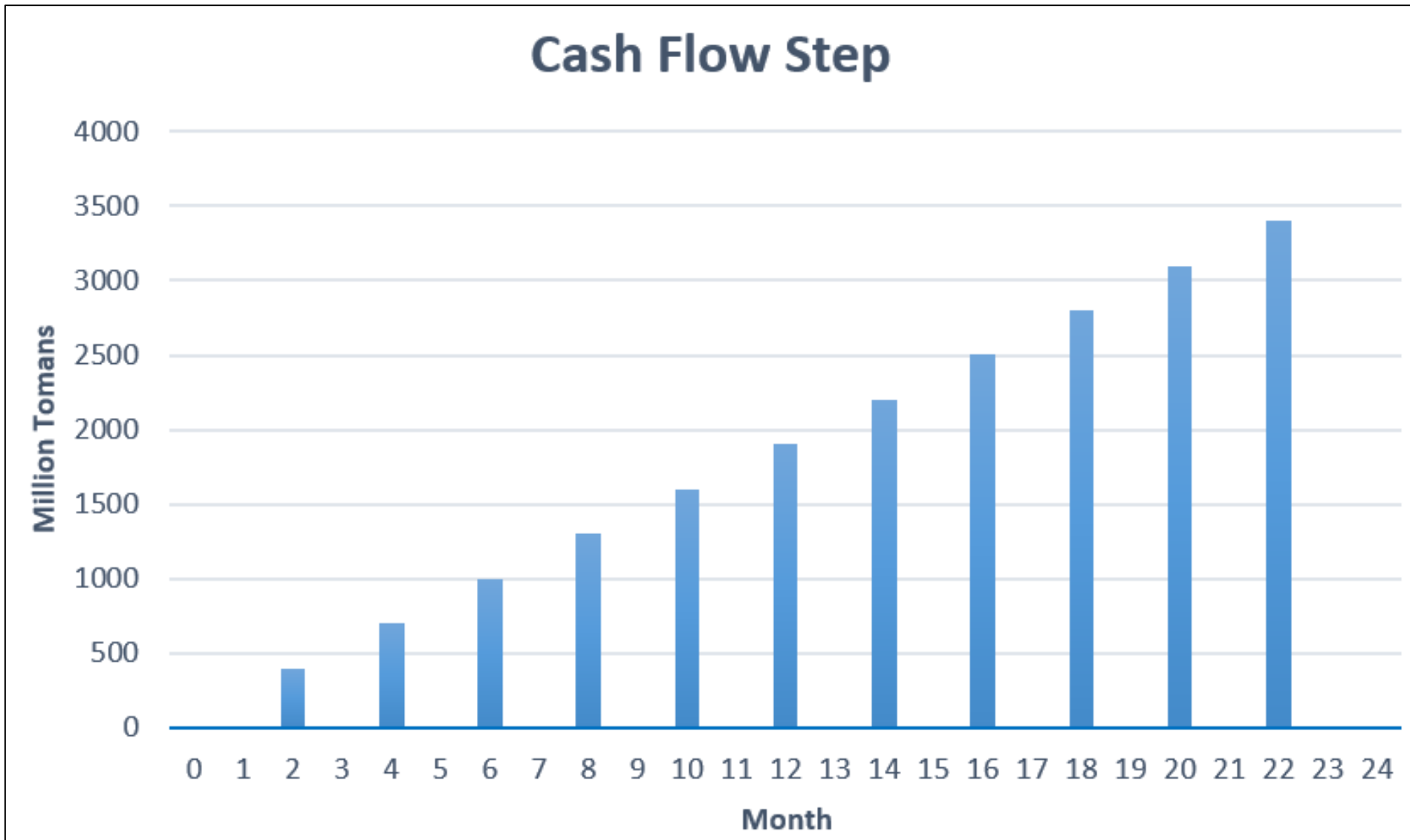


## (۲) جریان نقدینگی پله‌ای (Cash Flow Step)

| Type | No. | Description                  | Parameter | Value | Unit           |
|------|-----|------------------------------|-----------|-------|----------------|
| Step | 1   | Start Time of Cash Flow Step | STCFS     | 2     | Month          |
|      | 2   | End Time of Cash Flow Step   | ETCFS     | 22    | Month          |
|      | 3   | Frequency of Cash Flow Step  | FQCFS     | 2     | Month          |
|      | 4   | First Value of Step          | FVS       | 400   | Million Tomans |
|      | 5   | Cash Flow Step               | CFS       | 300   | Million Tomans |

|   | B                      | D        | E    | F    | G    | H    | I    | J    | K    | L    |
|---|------------------------|----------|------|------|------|------|------|------|------|------|
| 1 | Month                  | 0        | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    |
| 2 | Capex                  | 3000     | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| 3 | Cash Flow Step         | 0        | 0    | 400  | 0    | 400  | 0    | 400  | 0    | 400  |
| 4 | Cash Flow Step Counter | 0        | 0    | 1    | 1    | 2    | 2    | 3    | 3    | 4    |
| 5 | Updated Cash Flow Step | 0        | 0    | 400  | 0    | 700  | 0    | 1000 | 0    | 1300 |
| 6 | P/F                    | 1.00     | 0.99 | 0.98 | 0.96 | 0.95 | 0.94 | 0.93 | 0.92 | 0.91 |
| 7 | Net Value              | -3000    | 0    | 400  | 0    | 700  | 0    | 1000 | 0    | 1300 |
| 8 | NPV                    | 14353.52 |      |      |      |      |      |      |      |      |

## ۲) جریان نقدینگی پله‌ای (Cash Flow Step): نمودار



## ۲) جریان نقدینگی پله‌ای (Cash Flow Step): فرمول

|   | B                      | D      |
|---|------------------------|--------|
| 1 | Month                  | 0      |
| 2 | Capex                  | 3000   |
| 3 | Cash Flow Step         | 0      |
| 4 | Cash Flow Step Counter | 0      |
| 5 | Updated Cash Flow Step | 0      |
| 6 | P/F                    | 1.00   |
| 7 | Net Value              | -3000  |
| 8 | NPV                    | 461.44 |

=SUMPRODUCT(  
 OFFSET(\$C4,0,0,1,NP+1),  
 OFFSET(\$C5,0,0,1,NP+1))

=IF(D1>NP,"",IF(D1=0,Capex,0))

=IF(D1>NP,"",  
 IF(D1<STCFS,0,  
 IF(D1>ETCFS,0,  
 IF(MOD(D1-STCFS,FQCFS)=0,FVS,0))))

=IF(D1>NP,"",COUNTIF(\$D\$3:D3,"<>0"))






=IF(D1>NP,"",  
 IF(AND(D3<>0,D4=1),D3,  
 IF(AND(D3<>0,D4>1),D3+CFS\*(D4-1),0)))

=IF(C1>NP,"",1/(1+MARRM)^C1)

=IF(C1>NP,"",C5-C2)

## ٣) جریان نقدینگی شیبدار (Cash Flow Gradient)

| Type     | No. | Description                      | Parameter | Value | Unit           |
|----------|-----|----------------------------------|-----------|-------|----------------|
| Gradient | 1   | Start Time of Cash Flow Gradient | STCFG     | 2     | Month          |
|          | 2   | End Time of Cash Flow Gradient   | ETCFG     | 24    | Month          |
|          | 3   | Frequency of Cash Flow Gradient  | FQCFG     | 2     | Month          |
|          | 4   | First Value of Gradient          | FVG       | 400   | Million Tomans |
|          | 5   | Cash Flow Gradient               | CFG       | 30%   | Million Tomans |

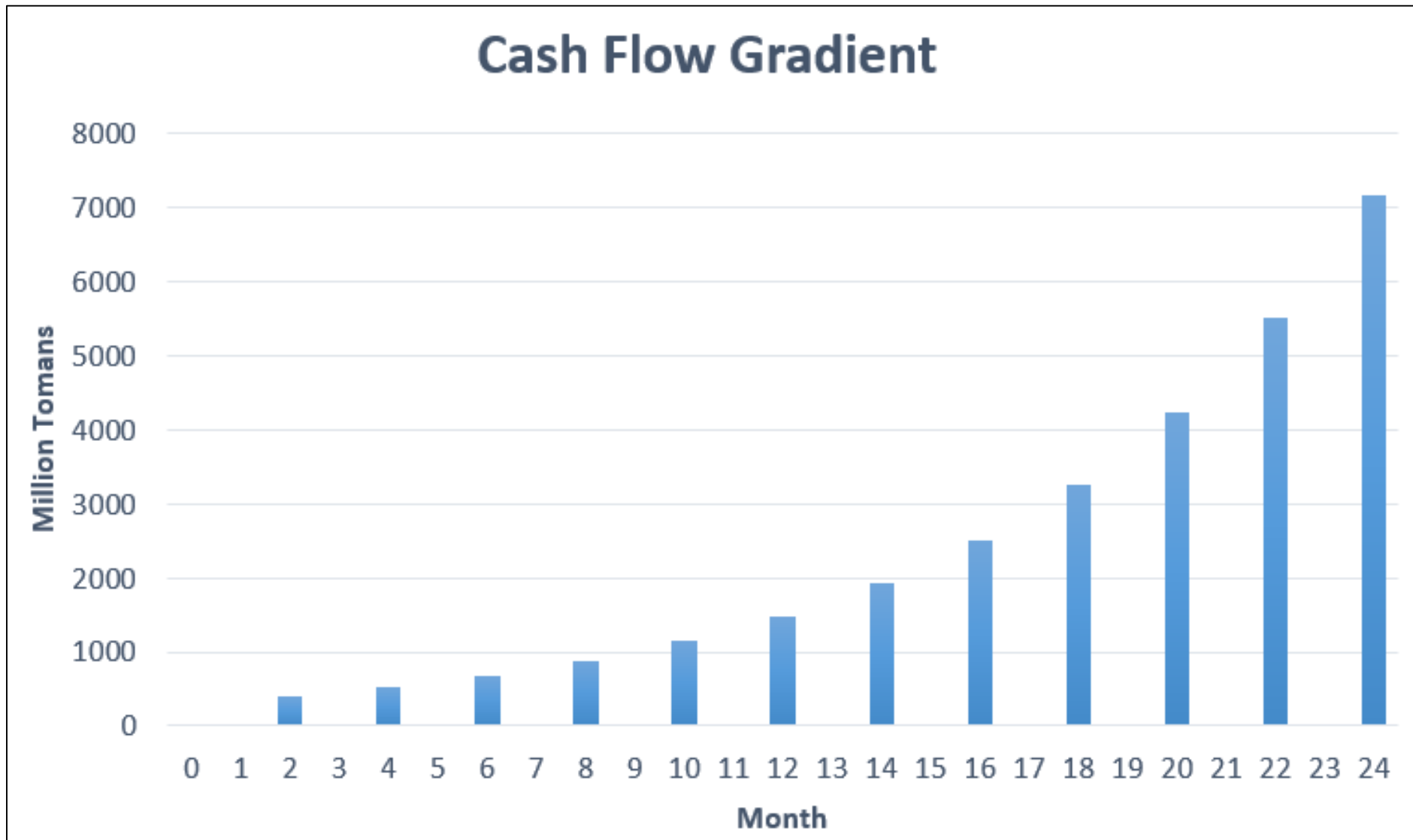
| Name  | Value | Refers To      | Scope    | Comment  |
|---|-------|----------------|----------|----------|
|  CFG     | 30%   | =Input!\$E\$19 | Workbook | Gradient |
|  ETCFG  | 24    | =Input!\$E\$16 | Workbook | Gradient |
|  FQCFG | 2     | =Input!\$E\$17 | Workbook | Gradient |
|  FVG   | 400   | =Input!\$E\$18 | Workbook | Gradient |
|  STCFG | 2     | =Input!\$E\$15 | Workbook | Gradient |

## (۳) جریان نقدینگی شیبدار (Cash Flow Gradient)

| Type     | No. | Description                      | Parameter | Value | Unit           |
|----------|-----|----------------------------------|-----------|-------|----------------|
| Gradient | 1   | Start Time of Cash Flow Gradient | STCFG     | 2     | Month          |
|          | 2   | End Time of Cash Flow Gradient   | ETCFG     | 24    | Month          |
|          | 3   | Frequency of Cash Flow Gradient  | FQCFG     | 2     | Month          |
|          | 4   | First Value of Gradient          | FVG       | 400   | Million Tomans |
|          | 5   | Cash Flow Gradient               | CFG       | 30%   | Million Tomans |

|   | B                          | D        | E    | F    | G    | H    | I    | J    | K    | L    | M    | N    |
|---|----------------------------|----------|------|------|------|------|------|------|------|------|------|------|
| 1 | Month                      | 0        | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   |
| 2 | Capex                      | 3000     | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| 3 | Cash Flow Gradient         | 0        | 0    | 400  | 0    | 400  | 0    | 400  | 0    | 400  | 0    | 400  |
| 4 | Cash Flow Counter Gradient | 0        | 0    | 1    | 1    | 2    | 2    | 3    | 3    | 4    | 4    | 5    |
| 5 | Updated Cash Flow Gradient | 0        | 0    | 400  | 0    | 520  | 0    | 676  | 0    | 879  | 0    | 1142 |
| 6 | P/F                        | 1.00     | 0.99 | 0.98 | 0.96 | 0.95 | 0.94 | 0.93 | 0.92 | 0.91 | 0.89 | 0.88 |
| 7 | Net Value                  | -3000    | 0    | 400  | 0    | 520  | 0    | 676  | 0    | 879  | 0    | 1142 |
| 8 | NPV                        | 20710.59 |      |      |      |      |      |      |      |      |      |      |

## ۳) جریان نقدینگی شیبدار (Cash Flow Gradient): نمودار



# ۳) جریان نقدینگی شیبدار (Cash Flow Gradient): فرمول

|   | B                          | D      |
|---|----------------------------|--------|
| 1 | Month                      | 0      |
| 2 | Capex                      | 3000   |
| 3 | Cash Flow Gradient         | 0      |
| 4 | Cash Flow Counter Gradient | 0      |
| 5 | Updated Cash Flow Gradient | 0      |
| 6 | P/F                        | 1.00   |
| 7 | Net Value                  | -3000  |
| 8 | NPV                        | 308.41 |

=SUMPRODUCT(  
 OFFSET(\$C4,0,0,1,NP+1),  
 OFFSET(\$C5,0,0,1,NP+1))

=IF(D1>NP,"",IF(D1=0,Capex,0))

=IF(D1>NP,"",  
 IF(D1<STCFG,0,  
 IF(D1>ETCFG,0,  
 IF(MOD(D1-STCFG,FQCFG)=0,FVG,0))))

=IF(D1>NP,"",COUNTIF(\$D\$3:D3,"<>0"))

=IF(D1>NP,"",  
 IF(AND(D3<>0,D4=1),D3,  
 IF(AND(D3<>0,D4>1),FVG\*(1+CFG)^(D4-1),0)))

=IF(C1>NP,"",1/(1+MARRM)^C1)

=IF(C1>NP,"",C5-C2)