# IE2111 ISE Principles & Practice II
# Solutions to Tutorial #2

**Question 1.**

| | |
|---|---|
| Investment cost | $ 13,000,000 |
| Useful life | 15 years |
| Market value at end of useful life | $ 3,000,000 |
| Annual operating expenses | $ 1,000,000 |
| Overhaul cost – end of 5th year | $ 200,000 |
| Overhaul cost – end of 10th year | $ 550,000 |

*MARR* = 12%
Study period = 10 years

$$\begin{aligned} PW(12\%) &= -13{,}000{,}000 + 3{,}000{,}000\ [P/F,12\%,15] - 1{,}000{,}000\ [P/A,12\%,15] \\ &\quad - 200{,}000\ [P/F,12\%,5] - 550{,}000\ [P/F,12\%,10] \\ &= -13{,}000{,}000 + 3{,}000{,}000\ (0.182696) - 1{,}000{,}000\ (6.810864) \\ &\quad - 200{,}000\ (0.567427) - 550{,}000\ (0.321973) \\ &= -19{,}553350 \end{aligned}$$

Hence the Power Plant has $PW(12\%) = \mathbf{-\$\ 19{,}553{,}350}$
PW
Note that this is a cost or service project, i.e., although its *PW* is negative, it contributes indirectly to other parts of the company's operations.

**Question 2.**

| | |
|---|---|
| Investment Cost | $10,000 |
| Expected life | 5 years |
| Salvage value* | - $1,000 |
| Annual receipts | $8,000 |
| Annual expenses | $4,000 |

*MARR* = 15%.
Study period = 5 years

*FW* at end of 5 years

$$\begin{aligned} &= -10{,}000\ [F/P,15\%,5] + (8{,}000 - 4{,}000)\ [F/A,15\%,5] - 1{,}000 \\ &= -10{,}000\ (2.011357) + (4{,}000)\ (6.742381) - 1{,}000 \\ &= \mathbf{\$\ 5{,}855.95 > 0} \end{aligned}$$

The project is acceptable at *MARR* = 15%.

**Question 3.**

**Capital Investments**

1. Land cost = $300,000
2. Building cost = $600,000
3. Equipment cost = $250,000
4. Working capital = $100,000

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Total Capital Investment = $1,250,000

**Annual Revenue & Expenses**

1. Annual revenue = $750,000
2. Annual expense = $475,000

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Annual Net Income = $275,000

**Salvage values at end of 10 years**

1. Land = $400,000
2. Building = $350,000
3. Equipment = $ 50,000

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Total Salvage Values = $800,000

Working capital recovered at EoY 10 = $100,000

*MARR* = 15%
Study period = 10 years.

$$AW(15\%) = -1{,}250{,}000\,[A/P, 15\%, 10] + 275{,}000 + (800{,}000 + 100{,}000)\,[A/F, 15\%, 10]$$
$$= -1{,}250{,}000\,(0.199252063) + 275{,}000 + 900{,}000\,(0.049252063)$$
$$= \$\,\mathbf{70{,}261.78} > 0$$

Therefore, the project is feasible and the company should invest in the new product line

**Question 4.**

Initial investment for solar panels = \$1,400
Monthly savings = \$24
Useful life = 7 years = 84 months
Salvage value = 0.
Study period = 7 years.

The *MARR* = 3% per year compounded monthly
= 0.25% per month compounded monthly

**(*a*) Discounted payback period**

Let $PW(i\%, k)$ = *PW* of the cash flows up to end of month $k$
$= -1{,}400 + 24\,[P/A, 0.25\%, k\,]$ for $k = 1$ to 84

The value of $PW(0.25\%, k)$ for $k = 60$ to 65 are as follows:

| $k$ | $PW(k)$ | Sign |
|---|---|---|
| 60 | -\$64.34 | < 0 |
| 61 | -\$43.73 | < 0 |
| 62 | -\$23.18 | < 0 |
| 63 | -\$2.67 | < 0 |
| 64 | \$17.79 | > 0 |
| 65 | \$38.19 | > 0 |

We note that $PW(25\%, 63 \text{ months}) < 0$ and $PW(25\%, 64) > 0$.

Hence the discounted payback period = 64 months at *MARR* = 0.25% per month.

**(*b*) Project *IRR***

*IRR* of the project is the solution to the equation:

$$-1{,}400 + 24\,[P/A/\, i\%, 84] = 0$$

$$[P/A/\, i\%, 84] = 58.33333333$$

By trial and error:

$$[P/A, 0.75\%, 84] = 62.1539646$$
$$\Leftarrow\ 58.3333333\ =\ [P/A/\, i\%, 84]$$
$$[P/A, 1\%, \quad 84] = 56.6484528$$

By linear interpolation:

$$\frac{i - 0.75}{1.00 - 0.75} \approx \frac{62.1539646 - 58.3333333}{62.1539646 - 56.6484528}$$

$$i \approx 0.923\ \%\ \text{per month}$$

Note: Exact solution using Excel Rate or Goal Seek is *IRR* = 0.9199% per month.

**Question 5**

The cash flows for the projects are:

| End of Year | Cash flow ($) |
|---|---|
| 0 | -65,000 |
| 1 | 25,000 |
| 2 | 30,000 |
| 3 | 30,000 |
| 4 | 40,000 |
| 5 | 46,000 |

*MARR* = 18% per year.
Study period = 5 years.

**(*a*)**

$$FW(18\%) = -65{,}000\,[F/P, 18\%, 5] + 25{,}000\,[F/P, 18\%, 4] + 30{,}000\,[F/P, 18\%, 3] + 30{,}000\,[F/P, 18\%, 2] + 40{,}000\,[F/P, 18\%, 1] + 46{,}000$$

$$= -65{,}000\,(1.18)^5 + 25{,}000\,(1.18)^4 + 30{,}000\,(1.18)^3 + 30{,}000\,(1.18)^2 + 40{,}000\,(1.18) + 46{,}000$$

$$= \underline{\mathbf{\$\ 84{,}028.15}} > 0$$

Hence the project is acceptable at *MARR* = 18%

**(*b*) Internal Rate of Return**

*IRR* is the solution to:

$$FW(i) = -65{,}000\,(1+i)^5 + 25{,}000\,(1+i)^4 + 30\,(1+i)^3 + 30{,}000\,(1+i)^2 + 40{,}000\,(1+i) + 46{,}000 = 0$$

By trial and error and linear interpolation (within the interval 35% to 40%)

$FW(35\%) = +\$\ 20{,}061.73 > 0$
$FW(40\%) = -\$\ 10{,}425.60 < 0$

$$IRR \approx 35\% + \frac{(0 - 20{,}061.73)}{(-10{,}425.60 - 20{,}061.73)}(40\% - 35\%)$$
$$= 38.3\% > MARR = 18\%$$

Hence the project is acceptable since *IRR* > *MARR*.

Note that the actual *IRR* = 38.402% using Excel or Python.

**(*c*) Modified Internal Rate of Return**

Financing rate = 12%
Reinvestment rate = 18%

*PW*(12%) of all *–ve* cash flows = - $65,000

*FW*(18%) of all *+ve* cash flows
= 25,000 $(1.18)^4$ + 30,000 $(1.18)^3$ + 30,000 $(1.18)^2$ + 40,000 (1.18) + 46,000
= $ 232,732.40

*MIRR* at financing rate 12% and reinvestment rate 18%

$$= \sqrt[5]{\frac{232{,}732.40}{65{,}000}} - 1 = 0.29059 \quad \text{or} \quad \underline{\mathbf{29.059\%}}$$

**(*d*) Discounted payback period.**

Compute $PW_k(18\%) = \sum_{j=0}^{k} \frac{CF_j}{(1+0.18)^j}$, for $k = 0, 1, \ldots, 5$.

| EoY | Cash Flow ($) | $PW_k(18\%)$ | *Sign* |
|---|---|---|---|
| 0 | −65,000.00 | −65,000.00 | < 0 |
| 1 | 25,000.00 | −43,813.56 | < 0 |
| 2 | 30,000.00 | −22,268.03 | < 0 |
| 3 | 30,000.00 | −4,009.10 | < 0 |
| 4 | 40,000.00 | +16,622.45 | > 0 |
| 5 | 46,000.00 | +36,729.48 | > 0 |

Discounted payback period = 4 years < 5 years.

Hence the project is acceptable based on discounted payback period at *MARR*=18%.