TIE2140 Engineering Economy
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 $PW(12\%) = \underline{\mathbf{-\$\ 19{,}553{,}350}}$
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

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

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

Total Capital Investment = $1,250,000

Annual Revenue & Expenses

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

Annual Net Income = $275,000

Salvage values at end of 10 years

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

Total Salvage Values = $800,000

Working capital recovered at EoY 10 = $100,000

MARR = 15%
Study period = 10 years.

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

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%.