# Engineering Economics

*1. Your company has asked you to evaluate two electrostatic copy machines from an economic standpoint. Machine A rents for $100 per month and has a total cost per copy of 8 cents including labor costs of waiting for the finished copy. Machine B rents for $300 per month and has a total cost per copy of 3 cents including labor charges.

(a) Find the standoff (either machine acceptable) quantity of monthly copies.

(b) Which machine would be preferable if you estimate 3000 copies per month?

*2. What would be the value in 6 years of $1000 compounded annually at 7% interest?

*3. How much is $1000 four years from now worth to you at 6% interest compounded annually?

*4. If you make 5 end of year deposits of $100 each to an annually compounded account at 6% interest how much will you have at the end of the 5th year?

*5. How much are 7 end of year payments of $1000 each worth to you now with annual compounding at 8% interest?

*6. If you borrow $10,000 and repay it in 5 end of year equal payments with annual compounding at 6% interest how much will the payments be?

*7. How much would you have to deposit at the end of each year for 6 years to accumulate $1000 for equipment overhaul? Compoundng is annual at 10% interest.

8. You have the opportunity to purchase a $10,000 sewer bond from the city of New Horizon which pays 5% interest annually on the face value of the bond; the bond is redeemable at face value in 20 years. Find the maximum price you would pay for the bond assuming your money value at 10% interest rate.

*9. Find the nominal and effective annual interest rates for a credit system that charges 1½% per month for its money use.

*10. A small manufacturing process has a first cost of $100,000 a life of 10 years, and a $10,000 salvage value. The revenues each year are $50,000 and the annual disbursements are $20,000. At a 20% cost of money find:

(a) the present equivalent.

(b) the annual equivalent.

11. A land speculator states that he just sold a property for a profit of $10,000. Each year of ownership he received the rental income of $400 and paid property taxes of $100. He has computed his rate of return to be exactly 10% on the investment he made 20 years ago. What was the original investment.

12. A municipal tax exempt electric utility is faced with the following annual frequency of power outage and cost characteristics for a particular industrial park it serves:

| Number of Outages | Probability of This Number During the Year | Cost of This Number of Outages to the Utility Company |
|---|---|---|
| 0 | .3 | $ 0 |
| 1 | .3 | $ 1,000 |
| 2 | .2 | $ 2,000 |
| 3 | .1 | $ 5,000 |
| 4 | .1 | $10,000 |

Note that the cost per failure increases for more numerous outages during the year due to contractual commitments guaranteeing power to a cookie manufacturer and also to a semi-conductor manufacturer. By installing a backup system the above probabilities are changed to the following:

$$P(0) = .7,\ P(1) = .2,\ P(2) = .1,\ P(3) = P(4) = 0$$

Assume the backup system will have a life of 20 years with no salvage value and annual maintenance will be $300. Find the maximum amount of money the utility could afford to spend on this backup system at a 10% interest rate.

13. The city of New Horizon is currently spending $15 per ton to process household refuse at the local landfill. A refuse resource recovery system is being proposed to the city that will yield equivalent value of $10 per ton of refuse including the energy extracted and the processed materials. The plant will have an installed cost of $500,000, with an estimated life of 20 years, and no salvage value. The annual operating costs are estimated at $10,000 plus $5 per ton. At a 10% interest rate find the minimum annual amount of refuse that must be processed to make this resource recovery system economically competitive with the landfill operation.

*14. Reconsider problem #10 with income tax effects. Find the present equivalent at 20% interest and a tax rate of 40% for:

(a) Straight line depreciation.

(b) Sum of year's digits.

(c) Double rate declining balance.

Formulas

$$(f/p)^i_n = (1 + i)^n$$

$$(p/f)^i_n = \frac{1}{(1 + i)^n}$$

$$(p/a)^i_n = \frac{(1 + i)^n - 1}{i(1 + i)^n}$$

$$(a/p)^i_n = \frac{i(1 + i)^n}{(1 + i)^n - 1}$$

$$(f/a)^i_n = \frac{(1 + i)^n - 1}{i}$$

$$(a/f)^i_n = \frac{i}{(1 + i)^n - 1}$$

**ENGR 401 Engineering Economics**

**Review Questions for Test 1**

*Calculate the Net Present Worth (NPW) for each of the following cash flows. Calculate for 5 years with a 15% cost of money. Include a cash flow diagram for each problem.*

A: Your computer initially costs $2000, and you will be receiving an income from typed reports once a year totaling $597.

B. Your computer initially costs $2000, and you will be receiving an income from typed reports once a year for $425 and increasing by $100 after the first year.

C. Your computer initially costs $2000, and you will be receiving an income from typed reports according to the following schedule: $500 for the first two years, $927 the 3rd, and decreasing by $400 the 4th and 5th year.

D. Your computer initially costs $2000, and you will be receiving an income from typed reports at the end of the 2nd year in the amount of $!000, $1424 for the 3rd year , and $1000 for the 4th.

E. Based on the following discussions, which cash flow has the greatest Net Present Worth?

*A dam was constructed for $200,000. The annual maintenance cost is $5000. If interest is at 5%, the capitalized cost of the dam, including maintenance is:

$$\text{Capitalized Cost} = \$200{,}000 + \frac{\$5000}{0.05} = \$300{,}000$$

*A Steam boiler is purchased on the basis of guaranteed performance. A test indicates that the operating cost will be $300 more per year than the manufacturer guaranteed. If the expected life of the boiler is 20 years and money is worth 8%, how much should the purchaser deduct from the purchase price to compensate for the extra operating cost?

$$P = A(P/A,\ 1\%,\ N) = 300\ (P/A,\ 8\%,\ 20) = 300\ (9.8181) = \$2{,}945.43$$

*A man buys a small garden tractor. There will be no maintenance cost the first year as the tractor is sold with one year's free maintenance. The second year the maintenance is estimated at $20. Insubsequent years the maintenance cost will increase $20 per year (i.e., 3rd year maintenance = $40; 4th year maintenance = $60, etc.). How much would need to be set aside now at 5% interest to pay the maintenance costs on the tractor for the first six years of ownership?

$$\begin{aligned} P &= \$20(P/F,5\%,2) + \$40(P/F,5\%,3) + \$60(P/F,5\%,4) + \$80(P/F,5\%,5) + \$100(P/F,5\%,6) \\ &= 20(0.9070) + 40(0.8636) + 60(0.8227) + 80(0.7835) + 100(0.7462) \\ &= 18.14 + 34.55 + 49.36 + 62.68 + 74.62 \\ &= \$239.35 \end{aligned}$$

OR

Using Gradient Table

$$P = G(P/G,\ 5\%,6)$$

$$= \$20(11.968)$$

$$= \$239.35$$

*Motors from two different manufacturers are being considered for an application. Both motors are 50HP, 460 volts, 3 phase, 60 cycle, but Motor A operates at 80% efficiency whereas Motor B operates at 88% efficiency. The expected need for motors is 15 years. Motor A costs $600 and Motor B costs $750. Electrical energy costs 2.0 cents/kwh. and the motors will be operated 8 hours per day, 250 days per year. Assume taxes at 3%. Which motor should be purchased? WHY?

Assumptions

1 horsepower = 0.746 kilowatts
Assume money at 6% per year

Annual Power Consumption

Motor A:

$$\frac{50\ HP}{0.80\ eff} \times \frac{0.746KW}{HP} \times \frac{8\ hrs.}{day} \times \frac{250\ days}{year} \times \frac{0.02\ dollars}{KWH} = \$1865.00$$

F. The effective interest rate is 19.56%. If there are 12 compounding periods per year, what is the nominal interest rate?

G. A young engineer wishes to buy a house but only can afford monthly payments of $500. Thirty year loans are available at 12% interest compounded monthly. If she can make a $5000 down payment, what is the price of the most expensive house that she can afford to purchase?

H. A store policy is to charge 1.25% interest each month on the unpaid balance. What are the nominal and effective interest?

I. Under what circumstances are the nominal and effective annual interest rates exactly equal; or is this never true?

J. E.X. Marc received a loan of $50 for the S.H. Ark Loan Company which he had to repay one month later with a single payment of $60. What was the nominal annual interest rate for this loan?

K. A local college parking enforcement bureau issues parking tickets which must be paid within one week. The person receiving the ticket may pay either $5 immediately, or $7 if payment is deferred one week. What nominal interest rate is implied in the arrangement?

Motor B:

$$\frac{50\ HP}{0.88\ eff} \times \frac{0.746\ KW}{HP} \times \frac{8\ hrs.}{day} \times \frac{250\ days}{year} \times \frac{0.02\ dollars}{KWh} = \$1704.51$$

Equivalent Uniform Annual Cost

Motor A:

| | | |
|---|---|---|
| Capital Recovery = $600(A/P, 6%,15) = $600(0.1030) | = $ | 61.80 |
| Taxes = $600(0.03) | = | 18.00 |
| Annual Power Cost | = | 1865.00 |
| ANNUAL COST | $ | 1944.80 |

Motor B:

| | | |
|---|---|---|
| Capital Recovery = $750(A/P,6%,15) = $750(0.1030) | = $ | 77.25 |
| Taxes = $750(0.03) | = | 22.50 |
| Annual Power Cost | = | 1704.51 |
| ANNUAL COST | $ | 1804.26 |

Based on assumptions made, Motor B should be purchased at a savings of $140.54 per year.

*A certain industrial firm desires an annual cost analysis to determine which of two different machines should be purchased. Each machine is capable of performing the same task in a given amount of time. Assume theminimum attractive rate of return is 6%.

| | Machine X | Machine Y |
|---|---|---|
| First Cost | $5,000 | $10,000 |
| Estimated Life | 5 yrs. | 12 yrs. |
| Salvage Value | None | $3,000 |
| Annual Maintenance Cost | $125 | $150 |

Annual Cost Comparison

Machine X:

| | | |
|---|---|---|
| Capital Recovery = $5000(A/P,6%,5) = 5000(0.2374) | = | $1187 |
| Annual Maintenance Cost | = | 125 |
| ANNUAL COST | = | $1312 |

Machine Y:

| | | |
|---|---|---|
| Capital Recovery = ($10,000-3,000)(A/P,6%,12) = ($7000)(0.1193) | | |
| Annual Interest on Salvage Value = $3000(0.06) | = $ | 835 |
| Annual Maintenance Cost | = | 180 |
| ANNUAL COST | = | 150 |
| | = | $1165 |

Select Machine Y (smaller annual cost)

*In building a highway, a highway commission is faced with the alternatives of building a 4-lane underpass that would take care of all future needs or building a 2-lane underpass now and a second 2-lane underpass 10 years later. The 4-lane underpass would cost $40,000 and have a maintenance cost of $1,000 per year during the 40 years it is expected an underpass will be needed. The 2-lane underpass will cost $27,000 each and each would have a maintenance cost of $800 per year. If financing costs are 6%, which alternative should be adopted? Assume zero salvage value for each alternative at the end of 40 years.

4-Lane:

| | | |
|---|---|---|
| First Cost | = | $40,000 |
| P.W. Maint. = $1000(P/A,6%,40) = 1000(15.05) | = | 15,050 |
| TOTAL P.W. COST | = | $55,050 |

Two 2-Lane:

| | | |
|---|---|---|
| First Cost of 1st | = | $27,000 |
| P.W. Maint. of 1st = $800(P/A,6%,40) | = | 12,040 |
| P.W. of 2nd = $27,000(P/F,6%,10) | = | 15,080 |
| P.W. Maint. of 2nd = $800(P/A,6%,30)(P/F,6%,10) | = | 6,140 |
| TOTAL P.W. COST | = | $60,260 |

Single 4-lane underpass is more economical.

STATISTICS

*Mean - is the average and is found by adding the values of the observations and then dividing by the number of objects observed.

*Mode - is the typical value and is the item that occurs most frequently

*Median - is the middle value and is a value which has an equal number of observations greater than and an equal number less than the value

*Range - is the difference between the largest and smallest observation

*The mean, mode, and median are measures of central tendency.

*The Range, Standard Deviation, and Variance are measures of dispersion about their mean (spread of observations).

## ENGINEERING ECONOMY

1. About how long will it take for $10,000 invested at 5% per year compounded annually to double in value?

   a) 5 years
   b) 10 years
   c) 15 years
   d) 20 years
   e) 25 years

2. If $200 is deposited in a savings account at the beginning of each of 15 years and the account draws interest at 7% per year compounded annually, the value of the account at the end of 15 years will be most nearly:

   a) $5,000
   b) $5,400
   c) $6,000
   d) $6,900
   e) $7,200

3. How many months at an interest rate of 1 percent per month does money have to be invested before it will double in value?

   a) 59 months
   b) 62 months
   c) 70 months
   d) 76 months
   e) 83 months

4. A department store charges one and one-half percent interest per month on credit purchases. This is equivalent to a nominal annual interest rate of

   a) 1.5 percent
   b) 15.0 percent
   c) 18.0 percent
   d) 19.6 percent
   e) 21.0 percent

5. A bank pays one percent interest on savings accounts four times a year. The effective annual interest rate is

   a) 1.00 percent
   b) 1.04 percent
   c) 3.96 percent
   d) 4.00 percent
   e) 4.06 percent

12. A sum of $1,000 is borrowed for one year at an interest rate of 1% per mo
If this same sum of money is borrowed for the same period at an interest
rate of 12% per annum, the saving in interest charges would be:

a) $ 0
b) $ 3
c) $ 5
d) $ 7
e) $14

13. Which of the following is NOT a method of depreciating plant equipment fo
accounting and engineering economic analysis purposes?

a) Double entry method
b) Fixed percentage method
c) Sum-of-year-digits method
d) Straight line method
e) Sinking fund method

14. What present sum would be needed to provide for annual end-of-year paymer
of $15 each forever? Assume interest is 6%.

a) $ 90.00
b) $150.00
c) $229.27
d) $250.00
e) $900.00

15. A dam was constructed for $200,000. The annual maintenance cost is $5,00
If interest is at 5 percent, the capitalized cost of the dam, including
maintenance, is:

a) $100,000
b) $200,000
c) $215,000
d) $250,000
e) $300,000

16. Given a sum of money Q that will be received six years from now. At 5
percent compound interest the present worth now of Q is $60.00. At th
same interest rate, what would be the value of Q ten years from now?

a) $ 60.00
b) $ 76.58
c) $ 90.00
d) $ 97.73
e) $120.00

DEPRECIATION METHODS

Terms

L = Useful life of structure in years
C = Original cost
d = Annual cost of depreciation
$C_A$ = Value at the end of A years
$C_L$ = Value at end of life structure (salvage value)
$D_A$ = Depreciation through year A

Straight-Line Method

$$d = \frac{C-C_L}{L} \qquad D_A = \frac{A(C-C_L)}{L} \qquad C_A = C - \frac{A(C-C_L)}{L}$$

Example

Determine the yearly cost of depreciation, salvage value at end of sixth year, and total depreciation up to end of sixth year on a structure that cost $120 new and has an estimated scrap value of $20 at end of 10 years.

$$d = \frac{\$120-\$20}{10} = \$10/\text{yr.} \qquad D_6 = \frac{6(\$120-20)}{10} = \$60 \qquad C_6 = \$120-\frac{6(\$120-20)}{10} = \$60$$

Fixed Percentage Method

The annual cost of depreciation is a fixed percentage of the salvage value at the beginning of the year. Does not consider scrap value.

$d_1 = Ck$ where k = depreciation constant

$d_A = (C_{A-1})k \qquad C_L = C(1-k)^L \qquad C_A = C(1-k)^A$

$$k = 1 - \sqrt[A]{\frac{C_A}{C}} = 1 - \sqrt[L]{\frac{C_L}{C}}$$

Example

Determine the depreciation charge for the sixth year and the salvage value at the end of the sixth year for a structure that cost $120 when new and has an estimated life of 10 years. Scrap value at the end of itslife is $20 and k = 0.164.

$$C_5 = \$120(1 - 0.164)^5 = 120(0.4085) = \$49.02$$

$$d_6 = (\$49.02)(k) = (49.02)(.164) = \$8.04$$

$$C_6 = \$120(1 - 0.164)^6 = \$40.98$$

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*A Steam boiler is purchased on the basis of guaranteed performance. A test indicates that the operating cost will be $300 more per year than the manufacturer guaranteed. If the expected life of the boiler is 20 years and money is worth 8%, how much should the purchaser deduct from the purchase price to compensate for the extra operating cost?

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Annual Power Consumption

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# Determining which of two competing methods is best

## Crossover CHart (break-even chart)

A basic design problem is whether to use general-purpose equipment (low capital costs but high operating costs) or special-purpose equipment (high capital costs but low operating costs). At some production quantity, the costs of the two methods are equal - this is the break-even point.

Example:

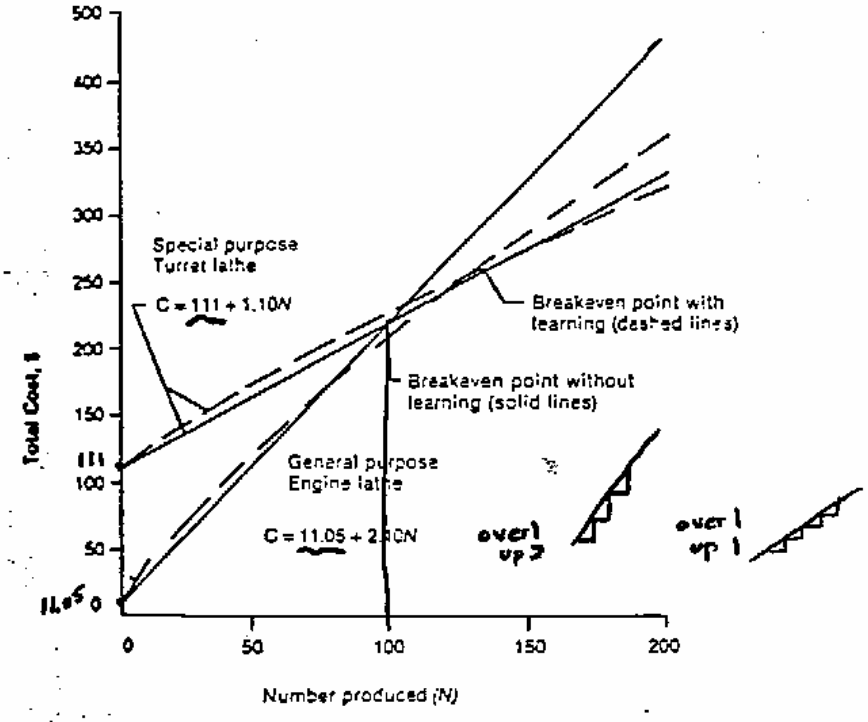
Using an engine lathe vs. a turret lathe.

**Information for Breakeven Example**

| Item | Engine Lathe | | Turret Lathe | |
|---|---|---|---|---|
| Machine cost, $/h | | | | |
| Capital (depreciation) | .50 | | 1.00 | |
| Other burden | 4.00 | 4.50 | 4.00 | 5.00 |
| Labor cost, $/h | | 6.00 | | 6.00 |
| Machine + labor, $/h | | 10.50 | | 11.00 |
| Fixed costs | | | | |
| Setup cost, h | .1 | | 1 | |
| Setup cost, $ | | 1.05 | | 11.00 |
| Tooling costs, $ | | 10.00 | | 100.00 |
| Total, $ | | 11.05 | | 111.00 |
| Variable costs | | | | |
| Manufacturing time, h | .2 | | .1 | |
| Mfg. variable cost, $/piece | | 2.10 | | 1.10 |

$11.05 + 2.1N = 111 + 1.00N$

$N = 100$ pieces



Engineering Economics Review
Answer Key

Engineering Economics Questions pages 187-188, numbers 1-14

1) a: Q=4000 copies/month
   b: Q=3000 copies/month → machine A would be lower cost
2) F=$1,501.00
3) P=$792.10
4) F=$563.70
5) P=$5206.00
6) A=$2,374.00
7) A=$129.61
8) P=$5733.00
9) i(nominal)=18% i(effective)=19.56%
10) a: P=$27,375.00 b: A=$6,533.20
11) P=$4,745.36
12) Expected outage cost of old system=$2,200
    Expected outage cost with proposed back-up system=$400
    Equate annual cost of old with new, expenditure <= $12,770.30
13) Q=3436 tons/year
14) a: P= -$7,837.80
    b: P= -$3,926.90
    c: P= -$3,234.40

Engr 401: Engineering Economics Review Questions for Test 1; Problems A-K

A) NPW= $1.14
B) NPW= $2.10
C) NPW= -$213.19
D) NPW= $264.08
E) cash flow D
F) nominal=18%
G) P=$53,609
H) effective=16.075%
I) When there is annual compounding
J) nominal=240%
K) nominal=2080%

Engineering Economy Questions 41-50

41) E
42) C
43) E
44) B
45) E

46) D
47) B
48) C
49) D
50) A

Engineering Economy; Problems 1-19

1) C
2) B
3) C
4) C
5) E
6) B
7) B
8) B
9) E
10) C
11) C
12) A
13) A
14) D
15) E
16) D
17) C
18) A
19) C

Crossover Chart (Break-even Chart)

$11.05 + 2.1N = 111 + 1.1N \rightarrow N = 99.95 \sim 100$ pieces