53 Comparison of Alternatives

Nomenclature

A	annual amount or annual value
B	present worth of all benefits
C	initial cost, or present worth of all costs
EUAC	equivalent uniform annual cost
F	future worth or future value
i	effective interest rate per period
MARR	minimum attractive rate of return
n	number of years
P	present worth or present value
PBP	pay-back period
ROR	rate of return

1. ALTERNATIVE COMPARISONS

In the real world, the majority of engineering economic analysis problems are alternative comparisons. In these problems, two or more mutually exclusive investments compete for limited funds. A variety of methods exists for selecting the superior alternative from a group of proposals. Each method has its own merits and applications.

2. PRESENT WORTH ANALYSIS

When two or more alternatives are capable of performing the same functions, the economically superior alternative will have the largest present worth. The *present worth method* is restricted to evaluating alternatives that are mutually exclusive and that have the same lives. This method is suitable for ranking the desirability of alternatives.

3. ANNUAL COST ANALYSIS

Alternatives that accomplish the same purpose but that have unequal lives must be compared by the *annual cost method*. The annual cost method assumes that each alternative will be replaced by an identical twin at the end of its useful life (i.e., infinite renewal). This method, which may also be used to rank alternatives according to their desirability, is also called the *annual return method* or *capital recovery method*.

The alternatives must be mutually exclusive and repeatedly renewed up to the duration of the longest-lived alternative. The calculated annual cost is known as the *equivalent uniform annual cost* (EUAC) or *equivalent annual cost* (EAC). Cost is a positive number when expenses exceed income.

4. RATE OF RETURN ANALYSIS

An intuitive definition of the *rate of return* (ROR) is the effective annual interest rate at which an investment accrues income. That is, the rate of return of an investment is the interest rate that would yield identical profits if all money was invested at that rate. Although this definition is correct, it does not provide a method of determining the rate of return.

The present worth of a \$100 investment invested at 5% is zero when $i = 5\%$ is used to determine equivalence. Therefore, a working definition of rate of return would be the effective annual interest rate that makes the present worth of the investment zero. Alternatively, rate of return could be defined as the effective annual interest rate that makes the benefits and costs equal.

A company may not know what effective interest rate, i, to use in engineering economic analysis. In such a case, the company can establish a minimum level of economic performance that it would like to realize on all investments. This criterion is known as the *minimum attractive rate of return*, or MARR.

Once a rate of return for an investment is known, it can be compared with the minimum attractive rate of return. If the rate of return is equal to or exceeds the minimum attractive rate of return, the investment is qualified (i.e., the alternative is viable). This is the basis for the rate of return method of alternative viability analysis.

If rate of return is used to select among two or more investments, an *incremental analysis* must be performed. An incremental analysis begins by ranking the alternatives in order of increasing initial investment. Then, the cash flows for the investment with the lower initial cost are subtracted from the cash flows for the higher-priced alternative on a year-by-year basis. This produces, in effect, a third alternative representing the costs and benefits of the added investment. The added expense of the higher-priced investment is not warranted unless the rate of return of this third alternative exceeds the minimum attractive rate of return as well. The alternative with the higher initial investment is superior if the incremental rate of return exceeds the minimum attractive rate of return.

Finding the rate of return can be a long, iterative process, requiring either interpolation or trial and error. Sometimes, the actual numerical value of rate of return is not needed; it is sufficient to know whether or not the rate of return exceeds the minimum attractive rate of return. This comparative analysis can be accomplished without calculating the rate of return simply by finding the present worth of the investment using the minimum attractive rate of return as the effective interest rate (i.e., $i = \text{MARR}$). If the present worth is zero or positive, the investment is qualified. If the present worth is negative, the rate of return is less than the minimum attractive rate of return and the additional investment is not warranted.

The present worth, annual cost, and rate of return methods of comparing alternatives yield equivalent results, but they are distinctly different approaches. The present worth and annual cost methods may use either effective interest rates or the minimum attractive rate of return to rank alternatives or compare them to the MARR. If the incremental rate of return of pairs of alternatives are compared with the MARR, the analysis is considered a rate of return analysis.

5. BENEFIT-COST ANALYSIS

The *benefit-cost ratio method* is often used in municipal project evaluations where benefits and costs accrue to different segments of the community. With this method, the present worth of all benefits (irrespective of the beneficiaries) is divided by the present worth of all costs. (Equivalent uniform annual costs can be used in place of present worths.) The project is considered acceptable if the ratio equals or exceeds 1.0 (i.e., $B/C \geq 1.0$). This will be true whenever $B - C \geq 0$.

When the benefit-cost ratio method is used, disbursements by the initiators or sponsors are *costs*. Disbursements by the users of the project are known as *disbenefits*. It is often difficult to determine whether a cash flow is a cost or a disbenefit (whether to place it in the denominator or numerator of the benefit-cost ratio calculation).

Regardless of where the cash flow is placed, an acceptable project will always have a benefit-cost ratio greater than or equal to 1.0, although the actual numerical result will depend on the placement. For this reason, the benefit-cost ratio alone should not be used to rank competing projects.

If ranking is to be done by the benefit-cost ratio method, an incremental analysis is required, as it is for the rate-of-return method. The incremental analysis is accomplished by calculating the ratio of differences in benefits to differences in costs for each possible pair of alternatives. If the ratio exceeds 1.0, alternative 2 is superior to alternative 1. Otherwise, alternative 1 is superior.

$$\frac{B_2 - B_1}{C_2 - C_1} \geq 1 \qquad 53.1$$

6. BREAK-EVEN ANALYSIS

Break-even analysis is a method of determining when the value of one alternative becomes equal to the value of another. It is commonly used to determine when costs exactly equal revenue. If the manufactured quantity is less than the *break-even quantity*, a loss is incurred. If the manufactured quantity is greater than the break-even quantity, a profit is made.

An alternative form of the break-even problem is to find the number of units per period for which two alternatives have the same total costs. Fixed costs are spread over a period longer than one year using the EUAC concept. One of the alternatives will have a lower cost if production is less than the break-even point. The other will have a lower cost if production is greater than the break-even point.

The *pay-back period*, PBP, is defined as the length of time, n, usually in years, for the cumulative net annual profit to equal the initial investment. It is tempting to introduce equivalence into pay-back period calculations, but the convention is not to.

$$C - (\text{PBP})(\text{net annual profit}) = 0 \qquad 53.2$$

SAMPLE PROBLEMS

Problem 1

A company purchases a piece of construction equipment for rental purposes. The expected income is \$3100 annually for its useful life of 15 years. Expenses are estimated to be \$355 annually. If the purchase price is \$25,000 and there is no salvage value, what is the prospective rate of return, neglecting taxes?

(A) 5.2%

(B) 6.4%

(C) 6.8%

(D) 7.0%

Solution

The rate of return can be viewed as the effective annual interest rate that makes the present worth of the investment equal to zero.

$$P = 0 = -\$25{,}000 + (\$3100)(P/A, i\%, 15) - (\$355)(P/A, i\%, 15)$$

$$\$25{,}000 = (\$2745)(P/A, i\%, 15)$$

$$9.1075 = (P/A, i\%, 15)$$

Use linear interpolation as an approximation.

$$(P/A, 6\%, 15) = 9.7122$$

$$(P/A, 8\%, 15) = 8.5595$$

$$\frac{9.7122 - 9.1075}{9.7122 - 8.5595} = 0.5245$$

$$i\% = 6\% + (0.5245)(8\% - 6\%) = 7.049\% \quad (7.0\%)$$

Answer is D.

Problem 2 through Prob. 4 refer to the following situation.

An industrial firm uses an economic analysis to determine which of two different machines to purchase. Each machine is capable of performing the same task in a given amount of time. Assume the minimum attractive rate of return is 8%.

Use the following data in this analysis.

	machine X	machine Y
initial cost	\$6000	\$12,000
estimated life	7 years	13 years
salvage value	none	\$4000
annual maintenance cost	\$150	\$175

Problem 2

What is the approximate equivalent uniform annual cost of machine X?

(A) \$1000

(B) \$1120

(C) \$1190

(D) \$1300

Solution

The approximate equivalent uniform annual cost is

$$(\text{EUAC})_X = (\$6000)(A/P, 8\%, 7) + \$150 = (\$6000)(0.1921) + \$150 = \$1302.60 \quad (\$1300)$$

Answer is D.

Problem 3

What is the approximate equivalent uniform annual cost of machine Y?

(A) \$1160

(B) \$1300

(C) \$1490

(D) \$1510

Solution

The equivalent uniform annual cost is

$$(\text{EUAC})_Y = (\$12{,}000)(A/P, 8\%, 13) + \$175 - (\$4000)(A/F, 8\%, 13) = (\$12{,}000)(0.1265) + \$175 - (\$4000)(0.0465) = \$1507 \quad (\$1510)$$

Answer is D.

Problem 4

Which, if either, of the two machines should the firm choose, and why?

(A) machine X because $(\text{EUAC})_X < (\text{EUAC})_Y$

(B) machine X because $(\text{EUAC})_X > (\text{EUAC})_Y$

(C) machine Y because $(\text{EUAC})_X < (\text{EUAC})_Y$

(D) machine Y because $(\text{EUAC})_X > (\text{EUAC})_Y$

Solution

$$(\text{EUAC})_X < (\text{EUAC})_Y$$

Machine X represents the superior alternative, based on a comparison of EUACs.

Answer is A.

Problem 5

Going Broke County is using a 10% annual interest rate to decide if it should buy snowplow A or snowplow B.

	snowplow A	snowplow B
initial cost	\$300,000	\$400,000
life	10 years	10 years
annual operations and maintenance	\$45,000	\$35,000
annual benefits	\$150,000	\$200,000
salvage value	\$0	\$10,000

What are the benefit-cost ratios for snowplows A and B, respectively, and which snowplow should Going Broke County buy?

Economics

(A) 2.2, 1.8; snowplow A

(B) 2.6, 2.1; snowplow A

(C) 1.4, 1.8; snowplow B

(D) 1.6, 2.0; snowplow B

Solution

The benefit-cost method requires the cash flows to be converted to present worths.

For snowplow A,

$$\begin{aligned} C &= \$300{,}000 + (\$45{,}000)(P/A, 10\%, 10) \\ &= \$300{,}000 + (\$45{,}000)(6.1446) \\ &= \$576{,}507 \\ B &= (\$150{,}000)(P/A, 10\%, 10) \\ &= (\$150{,}000)(6.1446) \\ &= \$921{,}690 \\ \frac{B}{C} &= \frac{\$921{,}690}{\$576{,}507} \\ &= 1.6 \end{aligned}$$

For snowplow B,

$$\begin{aligned} C &= \$400{,}000 + (\$35{,}000)(P/A, 10\%, 10) \\ &\quad - (\$10{,}000)(P/F, 10\%, 10) \\ &= \$400{,}000 + (\$35{,}000)(6.1446) - (\$10{,}000)(0.3855) \\ &= \$611{,}206 \\ B &= (\$200{,}000)(P/A, 10\%, 10) \\ &= (\$200{,}000)(6.1446) \\ &= \$1{,}228{,}920 \\ \frac{B}{C} &= \frac{\$1{,}228{,}920}{\$611{,}206} \\ &= (2.0) \end{aligned}$$

To rank the projects using the benefit-cost ratio method, use an incremental analysis. From Eq. 53.1,

$$\frac{B_2 - B_1}{C_2 - C_1} \geq 1 \quad \text{[for choosing alternative 2]}$$

$$\begin{aligned} \frac{B_2 - B_1}{C_2 - C_1} &= \frac{\$1{,}228{,}920 - \$921{,}690}{\$611{,}206 - \$576{,}507} \\ &= 8.85 > 1 \end{aligned}$$

The additional investment is warranted. Alternative 2 is superior; choose snowplow B.

Answer is D.

Problem 6

A company produces a gear that is commonly used by several lawnmower manufacturing companies. The base cost of operation (rent, utilities, etc.) is $750,000 per year. The cost of manufacturing is $1.35 per gear. If these gears are sold at $7.35 each, how many must be sold each year to break even?

(A) 65,000 per year

(B) 90,000 per year

(C) 100,000 per year

(D) 125,000 per year

Solution

The break-even point for this problem is the point at which costs equal revenues.

$$\begin{aligned} \text{costs} &= \$750{,}000 + (\$1.35)(\text{no. of gears}) \\ \text{revenues} &= (\$7.35)(\text{no. of gears}) \end{aligned}$$

$$\$750{,}000 + (\$1.35)(\text{no. of gears}) = (\$7.35)(\text{no. of gears})$$

$$\begin{aligned} \text{no. of gears} &= \frac{\$750{,}000}{\$7.35 - \$1.35} \\ &= 125{,}000 \end{aligned}$$

Answer is D.

FE-STYLE EXAM PROBLEMS

1. Calculate the rate of return for an investment with the following characteristics.

initial cost	$20,000
project life	10 years
salvage value	$5000
annual receipts	$7500
annual disbursements	$3000

(A) 19.6%

(B) 20.6%

(C) 22.9%

(D) 24.5%

2. Grinding mills M and N are being considered for a 12-year service in a chemical plant. The minimum attractive rate of return is 10%. What are the equivalent uniform annual costs of mills M and N, respectively, and which is the more economic choice?

	mill M	mill N
initial cost	$7800	$14,400
salvage value	$0	$2700
annual operating cost	$1745	$1200
annual repair cost	$960	$540

Economics

(A) $3840, $3620; mill N

(B) $3850, $3730; mill N

(C) $4330, $3960; mill N

(D) $3960, $5000; mill M

3. You want to purchase one of the following milling machines.

	machine A	machine B
initial cost	$20,000	$30,000
life	10 years	10 years
salvage value	$2000	$5000
annual receipts	$9000	$12,000
annual disbursements	$3500	$4500

What are the approximate rates of return for machines A and B, respectively?

(A) 22.5%, 28.2%

(B) 23.9%, 27.0%

(C) 24.8%, 22.1%

(D) 25.0%, 26.8%

4. Consider the two machines described in Prob. 3. If machine A is the preferred economic choice, what is the lowest value that the minimum attractive rate of return can be?

(A) 10%

(B) 17%

(C) 22%

(D) 25%

5. The annual maintenance cost of a machine shop is $10,000. The cost of making a forging is $2.00, and the selling price is $3.00. How many forgings should be produced each year in order to break even?

(A) 5000

(B) 10,000

(C) 13,000

(D) 17,000

For the following problems, use the NCEES Handbook as your only reference.

Problem 6 and Prob. 7 refer to the following situation.

A company plans to manufacture a product and sell it for $3.00 per unit. Equipment to manufacture the product will cost $250,000 and will have a net salvage value of $12,000 at the end of its estimated economic life of 15 years. The equipment can manufacture up to 2,000,000 units per year. Direct labor costs are $0.25 per unit, direct material costs are $0.85 per unit, variable administrative and selling expenses are $0.25 per unit, and fixed overhead costs are $200,000, not including depreciation.

6. If capital investments and return on the investment are excluded, what is the number of units that the company must manufacture and sell in order to break even with all other costs?

(A) 86,900

(B) 94,900

(C) 121,200

(D) 131,000

7. If straight-line depreciation is used, what is the number of units that the company must manufacture and sell to yield a before-tax profit of 20%?

(A) 187,700

(B) 203,000

(C) 225,300

(D) 270,000

8. Which of the following five situations are examples of making mutually exclusive decisions?

I. The maintenance department has requested a new air compressor and either a larger paint booth or an additional air compressor.

II. The machine shop needs new inspection and locating equipment.

III. The steno pool needs either a new, faster word processor or an additional office assistant.

IV. The budget committee must decide among building an employees' convenience store, an on-site cafeteria, an enclosed pool, or an in-house exercise room.

V. The newly elected union representative must resign due to a conflict of interest.

(A) I, II, and IV

(B) I, II, and V

(C) I, III, and IV

(D) II, III, and V

9. A particular gate valve can be repaired, replaced, or left alone. It will cost $12,500 to repair the valve and $25,000 to replace it. The cost due to a failure of the valve seat is $13,000; for a failure of the stem, $21,000; and for a failure of the body, $35,000. All amounts are the present values of all expected future costs. The probabilities of failure of the valve are known.

	valve component		
course of action	seat	stem	body
repair valve	50%	41%	21%
replace valve	35%	27%	9%
no action	65%	53%	42%

What plan of action should be chosen based on a present worth economic basis?

(A) Repair the valve.

(B) Replace the valve.

(C) Either repair or replace the valve.

(D) Do nothing.

10. Instead of paying $10,000 in annual rent for office space at the beginning of each year for the next 10 years, an engineering firm has decided to take out a 10-year, $100,000 loan for a new building at 6% interest. The firm will invest $10,000 of the rent saved and earn 18% annual interest on that amount. What will be the difference between the firm's annual revenue and expenses?

(A) The firm will need $3300 extra.

(B) The firm will need $1800 extra.

(C) The firm will break even.

(D) The firm will have $1600 left over.

Problem 11 through Prob. 13 refer to the following information.

An oil company is planning to install a new pipeline to connect storage tanks to a processing plant 1500 m away. Both 120 mm and 180 mm pipes are being considered.

	120 mm pipe	180 mm pipe
initial cost	$2500	$3500
service life	12 years	12 years
salvage value	$300	$400
annual maintenance	$300	$200
pump cost/hour	$1.40	$1.00
pump operation	600 hours/year	600 hours/year

For this analysis, the company will use an annual interest rate of 10%. Annual maintenance and pumping costs may be considered to be paid in their entireties at the end of the years in which their costs are incurred.

11. What is the approximate present worth of the 120 mm pipe over the first 12 years of operation?

(A) $9200

(B) $10,200

(C) $11,900

(D) $12,100

12. What is the present worth of the 180 mm pipe over the first 12 years of operation if operating costs increase by $0.75 (to $1.75 per hour) beginning in year 7?

(A) $8790

(B) $9010

(C) $9380

(D) $9930

13. If the annual benefit for the 180 mm pipe is $2000, what is the benefit-cost ratio?

(A) 1.10

(B) 1.35

(C) 1.49

(D) 1.54

14. A machine has an initial cost of $40,000 and an annual maintenance cost of $5000. Its useful life is 10 years. The annual benefit from purchasing the machine is $18,000. The effective annual interest rate is 10%. What is the machine's benefit-cost ratio?

(A) 1.51

(B) 1.56

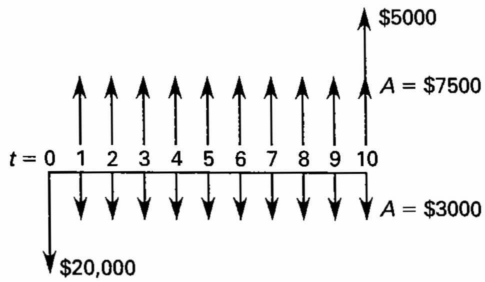
(C) 1.73

(D) 2.24

Economics

SOLUTIONS

1. For the investment,



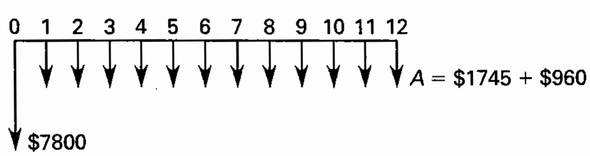
$$
\begin{aligned}
P = 0 &= -\$20{,}000 + (\$5000)(P/F, i\%, 10) \\
&\quad + (\$7500)(P/A, i\%, 10) \\
&\quad - (\$3000)(P/A, i\%, 10) \\
\$20{,}000 &= (\$5000)(P/F, i\%, 10) \\
&\quad + (\$4500)(P/A, i\%, 10) \\
&= (\$5000)(1+i)^{-10} \\
&\quad + (\$4500)\left(\frac{(1+i)^{10}-1}{i(1+i)^{10}}\right)
\end{aligned}
$$

By trial and error, $i = 19.6\%$.

The answer may also be obtained by linear interpolation of values from the discount factor tables, but this will not give an exact answer.

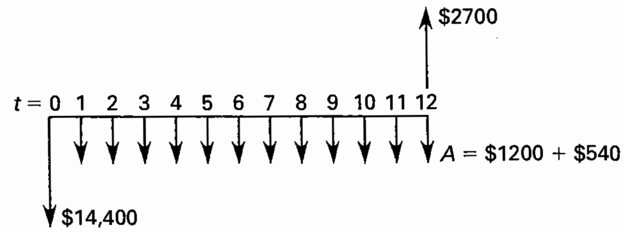
Answer is A.

2. For mill M,



$$
\begin{aligned}
(\text{EUAC})_\text{M} &= (\$7800)(A/P, 10\%, 12) + \$1745 + \$960 \\
&= (\$7800)(0.1468) + \$1745 + \$960 \\
&= \$3850
\end{aligned}
$$

For mill N,

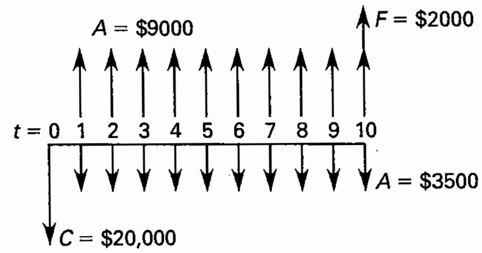


$$
\begin{aligned}
(\text{EUAC})_\text{N} &= (\$14{,}400)(A/P, 10\%, 12) \\
&\quad - (\$2700)(A/F, 10\%, 12) \\
&\quad + \$1200 + \$540 \\
&= (\$14{,}400)(0.1468) - (\$2700)(0.0468) \\
&\quad + \$1200 + \$540 \\
&= \$3728 \quad (\$3730) \\
&\quad \$3730 < \$3850
\end{aligned}
$$

Choose mill N.

Answer is B.

3. For machine A,

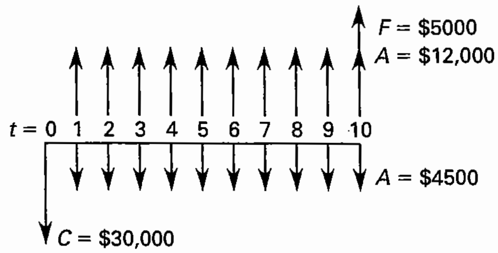


$$
\begin{aligned}
P = 0 &= -\$20{,}000 + (\$2000)(P/F, i\%, 10) \\
&\quad + (\$9000)(P/A, i\%, 10) \\
&\quad - (\$3500)(P/A, i\%, 10) \\
\$20{,}000 &= (\$2000)(P/F, i\%, 10) \\
&\quad + (\$5500)(P/A, i\%, 10) \\
&= (\$2000)(1+i)^{-10} \\
&\quad + (\$5500)\left(\frac{(1+i)^{10}-1}{i(1+i)^{10}}\right)
\end{aligned}
$$

By trial and error, $i = 24.8\%$.

Economics

For machine B,



$$\begin{aligned} P &= 0 \\ &= -\$30{,}000 + (\$5000)(P/F, i\%, 10) \\ &\quad + (\$12{,}000)(P/A, i\%, 10) \\ &\quad - (\$4500)(P/A, i\%, 10) \end{aligned}$$

$$\begin{aligned} \$30{,}000 &= (\$5000)(P/F, i\%, 10) \\ &\quad + (\$7500)(P/F, i\%, 10) \\ &= (\$5000)(1+i)^{-10} \\ &\quad + (\$7500)\left(\frac{(1+i)^{10}-1}{i(1+i)^{10}}\right) \end{aligned}$$

By trial and error, $i = 22.1\%$.

Answer is C.

4. To compare alternatives using rate of return, it is not appropriate to simply compare the rates of return. An incremental analysis must be performed.

Machine B initially costs more than machine A. Subtract the cash flows of machine A from those of machine B to obtain a third alternative representing the costs and benefits of the added investment.

$$\begin{array}{rl} \text{machine B:} & -\$30{,}000 + (\$5000)(P/F,\ i\%,\ 10) \\ & +(\$12{,}000)(P/A,\ i\%,\ 10) \\ & -(\$4500)(P/A,\ i\%,\ 10) \\ -\ \text{machine A:} & -\$20{,}000 + (\$2000)(P/F,\ i\%,\ 10) \\ & +(\$9000)(P/A,\ i\%,\ 10) \\ & -(\$3500)(P/A,\ i\%,\ 10) \\ \hline & -\$10{,}000 + (\$3000)(P/F,\ i\%,\ 10) \\ & +(\$3000)(P/A,\ i\%,\ 10) \\ & -(\$1000)(P/A,\ i\%,\ 10) \end{array}$$

Set the cash flows equal to zero and find the rate of return.

$$-\$10{,}000 + (\$3000)(1+i)^{-10} + (\$2000)\left(\frac{(1+i)^{10}-1}{i(1+i)^{10}}\right) = 0$$

By trial and error, $i = 16.9\%$ (17%).

For machine B to be worth the extra initial investment, the incremental rate of return must exceed the minimum attractive rate of return. If machine A is the preferred alternative, MARR > 17%.

Answer is B.

5. At the break even point, costs equal revenues.

$$\begin{aligned} \text{costs} &= \$10{,}000 + (\$2.00)(\text{no. of forgings}) \\ \text{revenues} &= (\$3.00)(\text{no. of forgings}) \\ \$10{,}000 + (\$2.00)(\text{no. of forgings}) &= (\$3.00)(\text{no. of forgings}) \\ \text{no. of forgings} &= \frac{\$10{,}000}{\$3.00 - \$2.00} = 10{,}000 \end{aligned}$$

Answer is B.

6. The cost is

$$\begin{aligned} \text{costs} &= \$200{,}000 + (\$0.25)(\text{no. of units}) \\ &\quad + (\$0.85)(\text{no. of units}) \\ &\quad + (\$0.25)(\text{no. of units}) \\ &= \$20{,}000 + (\$1.35)(\text{no. of units}) \\ \text{revenues} &= (\$3.00)(\text{no. of units}) \end{aligned}$$

$$\$200{,}000 + (\$1.35)(\text{no. of units}) = (\$3.00)(\text{no. of units})$$

$$\begin{aligned} \text{no. of units} &= \frac{\$200{,}000}{\$3.00 - \$1.35} \\ &= 121{,}212 \quad (121{,}000) \end{aligned}$$

Answer is C.

7. The cost per year is

$$\begin{aligned} D_j &= \frac{\$250{,}000 - \$12{,}000}{15\ \text{years}} \\ &= \$15{,}867\ \text{per year} \\ \text{costs} &= \$15{,}867 + \$200{,}000 + (\$1.35)(\text{no. of units}) \\ \text{revenues} &= (\$3.00)(\text{no. of units}) \end{aligned}$$

For a before-tax profit of 20% of costs,

$$\begin{aligned} (\$3.00)(\text{no. of units}) &= (1.2)\big(\$215{,}867 + (\$1.35)(\text{no. of units})\big) \\ \text{no. of units} &= \frac{(1.2)(\$215{,}867)}{\$3.00 - (1.2)(\$1.35)} \\ &= 187{,}710 \quad (187{,}700) \end{aligned}$$

Answer is A.

8. Alternatives are mutually exclusive when selecting one precludes the others. Situations I, III, and IV require a decision that will eliminate one part or another of the alternative. There is no alternative from which to choose in situations II and V.

Answer is C.

9. Determine the expected cost of each option. The expected cost of an event is the product of the probability and cost for that event.

$$\begin{aligned}\text{expected cost} &= \text{cost of option}\\ &\quad + p\{\text{seat failure}\}(\text{cost of seat failure})\\ &\quad + p\{\text{steam failure}\}(\text{cost of steam failure})\\ &\quad + p\{\text{body failure}\}(\text{cost of body failure})\end{aligned}$$

The cost to do nothing is

$$\begin{aligned}&\$0 + (0.65)(\$13{,}000) + (0.53)(\$21{,}000)\\ &\quad + (0.42)(\$35{,}000) = \$34{,}280\end{aligned}$$

The cost of repair is

$$\begin{aligned}&\$12{,}500 + (0.50)(\$13{,}000) + (0.41)(\$21{,}000)\\ &\quad + (0.21)(\$35{,}000) = \$34{,}960\end{aligned}$$

The cost to replace is

$$\begin{aligned}&\$25{,}000 + (0.35)(\$13{,}000) + (0.27)(\$21{,}000)\\ &\quad + (0.09)(\$35{,}000) = \$38{,}370\end{aligned}$$

The least expensive option is to do nothing.

Answer is D.

10. The annual loan payment will be

$$\begin{aligned}P(A/P, 6\%, 10) &= (\$100{,}000)(0.1359)\\ &= \$13{,}590\end{aligned}$$

The annual return from the investment will be

$$\begin{aligned}P(A/P, 18\%, 1) &= (\$10{,}000)(1.1800)\\ &= \$11{,}800\end{aligned}$$

The difference between the loan payment and the return on the investment is

$$\$13{,}590 - \$11{,}800 = \$1790 \quad (\$1800)$$

Answer is B.

11. The present worth over the first 12 years of operation is approximately

$$\begin{aligned}P &= \$2500 + (\$300)(P/A, 10\%, 12)\\ &\quad + \left(1.40\ \frac{\$}{\text{hour}}\right)\left(600\ \frac{\text{hours}}{\text{year}}\right)\\ &\quad \times (P/A, 10\%, 12)\\ &\quad - (\$300)(P/F, 10\%, 12)\\ &= \$2500 + (\$300 + \$840)(6.8137)\\ &\quad - (\$300)(0.3186)\\ &= \$10{,}172 \quad (\$10{,}200)\end{aligned}$$

Answer is B.

12. The present worth is

$$\begin{aligned}P &= \$3500 + (\$200)(P/A, 10\%, 12)\\ &\quad + \left(1.00\ \frac{\$}{\text{hour}}\right)(600\ \text{hours})(P/A, 10\%, 6)\\ &\quad + \left(1.75\ \frac{\$}{\text{hour}}\right)(600\ \text{hours})(P/A, 10\%, 12)\\ &\quad - \left(1.75\ \frac{\$}{\text{hour}}\right)(600\ \text{hours})(P/A, 10\%, 6)\\ &\quad - (\$400)(P/F, 10\%, 12)\\ &= \$3500 + (\$200)(6.8137)\\ &\quad + (\$600)(4.3553)\\ &\quad + (\$1050)(6.8137)\\ &\quad - (\$1050)(4.3553)\\ &\quad - (\$400)(0.3186)\\ &= \$9930\end{aligned}$$

Answer is D.

13. The effective uniform annual cost of the 180 mm pipe is

$$\begin{aligned}\text{EUAC} &= (\$3500)(A/P, 10\%, 12) + \$200\\ &\quad + \left(1.00\ \frac{\$}{\text{hour}}\right)(600\ \text{hours})\\ &\quad - (\$400)(A/F, 10\%, 12)\\ &= (\$3500)(0.1468) + \$200 + \$600\\ &\quad - (\$400)(0.0468)\\ &= \$1295\end{aligned}$$

The benefit-cost ratio of annual amounts is

$$B/C = \frac{\$2000}{\$1295} = 1.54$$

Answer is D.

Economics

14. The effective uniform annual cost for the machine is

$$\begin{aligned}\text{EUAC} &= (\$40{,}000)(A/P, 10\%, 10) + \$5000 \\ &= (\$40{,}000)(0.1627) + \$5000 \\ &= \$11{,}508 \\ B/C &= \frac{\$18{,}000}{\$11{,}508} \\ &= 1.56\end{aligned}$$

Answer is B.

Economics