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Chapter 37. Engineering Economic Analysis

Practice Problems

1.

At 6% effective annual interest, approximately how much will be accumulated if $1000 is invested for 10 years?

(A)

$560

(B)

$790

(C)

$1600

(D)

$1800

2.

At 6% effective annual interest, the present worth of $2000 that becomes available in four years is most nearly

(A)

$520

(B)

$580

(C)

$1600

(D)

$2500

3.

At 6% effective annual interest, approximately how much should be invested to accumulate $2000 in 20 years?

(A)

$620

(B)

$1400

(C)

$4400

(D)

$6400

4.

At 6% effective annual interest, the year-end annual amount deposited over seven years that is equivalent to $500 invested now is most nearly

(A)

$90

(B)

$210

(C)

$300

(D)

$710

5.

At 6% effective annual interest, the accumulated amount at the end of ten years if $50 is invested at the end of each year for ten years is most nearly

(A)

$90

(B)

$370

(C)

$660

(D)

$900

6.

At 6% effective annual interest, approximately how much should be deposited at the start of each year for 10 years (a total of 10 deposits) in order to empty the fund by drawing out $200 at the end of each year for 10 years (a total of 10 withdrawals)?

(A)

$190

(B)

$210

(C)

$220

(D)

$250
7.

At 6% effective annual interest, approximately how much should be deposited at the start of each year for five years to accumulate $2000 on the date of the last deposit?

(A)

$350

(B)

$470

(C)

$510

(D)

$680

8.

At 6% effective annual interest, approximately how much will be accumulated in 10 years if three payments of $100 are deposited every other year for four years, with the first payment occurring at $t = 0$?

(A)

$180

(B)

$480

(C)

$510

(D)

$540

9.

$500 is compounded monthly at a 6% nominal annual interest rate. Approximately how much will have accumulated in five years?

(A)

$515

(B)

$530

(C)

$675

(D)

$690
10.

The effective annual rate of return on an $80 investment that pays back $120 in seven years is most nearly

(A)

4.5%

(B)

5.0%

(C)

5.5%

(D)

6.0%

11.

A new machine will cost $17,000 and will have a resale value of $14,000 after five years. Special tooling will cost $5000. The tooling will have a resale value of $2500 after five years. Maintenance will be $2000 per year. The effective annual interest rate is 6%. The average annual cost of ownership during the next five years will be most nearly

(A)

$2000

(B)

$2300

(C)

$4300

(D)

$5500

12.

An old covered wooden bridge can be strengthened at a cost of $9000, or it can be replaced for $40,000. The present salvage value of the old bridge is $13,000. It is estimated that the reinforced bridge will last for 20 years, will have an annual cost of $500, and will have a salvage value of $10,000 at the end of 20 years. The estimated salvage value of the new bridge after 25 years is $15,000. Maintenance for the new bridge would cost $100 annually. The effective annual interest rate is 8%. Which is the best alternative?

(A)

Strengthen the old bridge.

(B)

Build the new bridge.

(C)

Both options are economically identical.

(D)

Not enough information is given.
13.

A firm expects to receive $32,000 each year for 15 years from sales of a product. An initial investment of $150,000 will be required to manufacture the product. Expenses will run $7530 per year. Salvage value is zero, and straight-line depreciation is used. The income tax rate is 48%. The after-tax rate of return is most nearly

(A)

8.0%

(B)

9.0%

(C)

10%

(D)

11%

14.

A public works project has initial costs of $1,000,000, benefits of $1,500,000, and disbenefits of $300,000. The excess of benefits over costs is most nearly

(A)

$200,000

(B)

$500,000

(C)

$700,000

(D)

$800,000

15.

A speculator in land pays $14,000 for property that he expects to hold for 10 years. $1000 is spent in renovation, and a monthly rent of $75 is collected from the tenants. (Use the year-end convention.) Taxes are $150 per year, and maintenance costs are $250 per year. In 10 years, the sale price needed to realize a 10% rate of return is most nearly

(A)

$26,000

(B)

$31,000
(C)

$34,000

(D)

$36,000
16.

The effective annual interest rate for a payment plan of 30 equal payments of $89.30 per month when a lump sum payment of $2000 would have been an outright purchase is most nearly

(A)

27%

(B)

35%

(C)

43%

(D)

51%

17.

A depreciable item is purchased for $500,000. The salvage value at the end of 25 years is estimated at $100,000. The depreciation in each of the first three years using the straight line method is most nearly

(A)

$4000

(B)

$16,000

(C)

$20,000

(D)

$24,000

18.

Equipment that is purchased for $12,000 now is expected to be sold after ten years for $2000. The estimated maintenance is $1000 for the first year, but it is expected to increase $200 each year thereafter. The effective annual interest rate is 10%. The present worth (cost) is most nearly

(A)

$16,000

(B)

$17,000
(C)

$21,000

(D)

$22,000
19.

A new grain combine with a 20-year life can remove seven pounds of rocks from its harvest per hour. Any rocks left in its output hopper will cause $25,000 damage in subsequent processes. Several investments are available to increase the rock-removal capacity, as listed in the table. The effective annual interest rate is 10%. What should be done?

rock removal rate	annual probability of exceeding rock removal rate	required investment to achieve removal rate
7	0.15	0
8	0.10	$15,000
9	0.07	$20,000
10	0.03	$30,000

(A)

Do nothing.

(B)

Invest $15,000.

(C)

Invest $20,000.

(D)

Invest $30,000.

20.

A mechanism that costs $10,000 has operating costs and salvage values as given. An effective annual interest rate of 20% is to be used.

year	operating cost	salvage value
1	$2000	$8000
2	$3000	$7000
3	$4000	$6000
4	$5000	$5000
5	$6000	$4000

The economic life of the mechanism is most nearly

(A)

one year

(B)

two years
(C)

three years

(D)

five years
21.

A salesperson intends to purchase a car for $50,000 for personal use, driving 15,000 miles per year. Insurance for personal use costs $2000 per year, and maintenance costs $1500 per year. The car gets 15 miles per gallon, and gasoline costs $1.50 per gallon. The resale value after five years will be $10,000. The salesperson's employer has asked that the car be used for business driving of 50,000 miles per year and has offered a reimbursement of $0.30 per mile. Using the car for business would increase the insurance cost to $3000 per year and maintenance to $2000 per year. The salvage value after five years would be reduced to $5000. If the employer purchased a car for the salesperson to use, the initial cost would be the same, but insurance and maintenance would be $2500 and $2000 respectively. The salesperson's effective annual interest rate is 10%. With a reimbursement of $0.30 per mile, approximately how many miles must the car be driven per year to justify the employer buying the car for the salesperson to use?

(A)

20,000 mi

(B)

55,000 mi

(C)

82,000 mi

(D)

150,000 mi

22.

Alternatives A and B are being evaluated. The effective annual interest rate is 10%.

	alternative A	alternative B
first cost	$80,000	$35,000
life	20 years	10 years
salvage value	$7000	0
annual costs		
years 1–5	$1000	$3000
years 6–10	$1500	$4000
years 11–20	$2000	0
additional cost		
year 10	$5000	0

Which alternative is economically superior?

(A)

Alternative A is economically superior.

(B)

Alternative B is economically superior.
(C)

Alternatives A and B are economically equivalent.

(D)

Not enough information is provided.
23.

A car is needed for three years. Plans A and B for acquiring the car are being evaluated. An effective annual interest rate of 10% is to be used.

Plan A: lease the car for $0.25/mile (all inclusive)

Plan B: purchase the car for $30,000; keep the car for three years; sell the car after three years for $7200; pay $0.14 per mile for oil and gas; pay other costs of $500 per year

Which plan is economically superior?

(A)

Plan A is economically superior.

(B)

Plan B is economically superior.

(C)

Plans A and B are economically equivalent.

(D)

Not enough information is provided.

24.

Two methods are being considered to meet strict air pollution control requirements over the next ten years. Method A uses equipment with a life of 10 years. Method B uses equipment with a life of five years that will be replaced with new equipment with an additional life of five years. Capacities of the two methods are different, but operating costs do not depend on the throughput. Operation is 24 hours per day, 365 days per year. The effective annual interest rate for this evaluation is 7%.

	method A	method B	
	years 1–10	years 1–5	years 6–10
installation cost	$13,000	$6000	$7000
equipment cost	$10,000	$2000	$2200
operating cost per hour	$10.50	$8.00	$8.00
salvage value	$5000	$2000	$2000
capacity (tons/yr)	50	20	20
life	10 years	5 years	5 years

The uniform annual cost per ton for method B is most nearly

(A)

$3500

(B)

$3600
(C)

$4200

(D)

$4300
25.

A transit district has asked for assistance in determining the proper fare for its bus system. An effective annual interest rate of 7% is to be used. The following additional information was compiled.

cost per bus	$60,000
bus life	20 years
salvage value	$10,000
miles driven per year	37,440
number of passengers per year	80,000
operating cost	$1.00 per mile in the first year, increasing $0.10 per mile each year thereafter

If the transit district decides to set the per-passenger fare at $0.35 for the first year, approximately how much should the passenger fare go up each year thereafter such that the district can break even in 20 years?

(A)

$0.022 increase per year

(B)

$0.036 increase per year

(C)

$0.067 increase per year

(D)

$0.072 increase per year

26.

Make a recommendation to your client to accept one of the following alternatives. Use the present worth comparison method. (Initial costs are the same.)

Alternative A: a 25-year annuity paying $4800 at the end of each year, where the interest rate is a nominal 12% per annum

Alternative B: a 25-year annuity paying $1200 every quarter at 12% nominal annual interest

(A)

Alternative A is economically superior.

(B)

Alternative B is economically superior.

(C)

Alternatives A and B are economically equivalent.

(D)

Not enough information is provided.
27.

A firm has two alternatives for improvement of its existing production line. The data are as follows.

	alternative A	alternative B
initial installment cost	$1500	$2500
annual operating cost	$800	$650
service life	5 years	8 years
salvage value	0	0

Determine the best alternative using an interest rate of 15%.

(A)

Alternative A is economically superior.

(B)

Alternative B is economically superior.

(C)

Alternatives A and B are economically equivalent.

(D)

Not enough information is provided.

28.

Two mutually exclusive alternatives requiring different investments are being considered. The life of both alternatives is estimated at 20 years with no salvage values. The minimum rate of return that is considered acceptable is 4%. Which alternative is best?

	alternative A	alternative B
investment required	$70,000	$40,000
net income per year	$5620	$4075
rate of return on total investment	5%	8%

(A)

Alternative A is economically superior.

(B)

Alternative B is economically superior.

(C)

Alternatives A and B are economically equivalent.

(D)

Not enough information is provided.

29.

Compare the costs of two plant renovation schemes, A and B. Assume equal lives of 25 years, no salvage values, and interest at 25%.

	alternative A	alternative B
first cost	$20,000	$25,000
annual expenditure	$3000	$2500

Determine the best alternative using the present worth method.

(A)

Alternative A is economically superior.

(B)

Alternative B is economically superior.

(C)

Alternatives A and B are economically equivalent.

(D)

Not enough information is provided.

30.

A machine costs $18,000 and has a salvage value of $2000. It has a useful life of eight years. The interest rate is 8%. Using straight line depreciation, its book value at the end of five years is most nearly

(A)

$2000

(B)

$3000

(C)

$6000

(D)

$8000

31.

A soda ash plant has the water effluent from processing equipment treated in a large settling basin. The settling basin eventually discharges into a river that runs alongside the basin. Recently enacted environmental regulations require all rainfall on the plant to be diverted and treated in the settling basin. A heavy rainfall will cause the entire basin to overflow. An uncontrolled overflow will cause environmental damage and heavy fines. The construction of additional height on the existing basin walls is under consideration.

Data on the costs of construction and expected costs for environmental cleanup and fines are shown. Data on 50 typical winters have been collected. The soda ash plant management considers 12% to be their minimum rate of return, and it is felt that after 15 years the plant will be closed. The company wants to select the alternative that minimizes its total expected costs.

additional basin height (ft)	number of winters with basin overflow	expense for environmental cleanup per year	construction cost
0	24	$550,000	0
5	14	$600,000	$600,000
10	8	$650,000	$710,000
15	3	$700,000	$900,00
20	1	$800,000	$1,000,000
	50		

The additional height the basin should be built to is most nearly

(A)

5.0 ft

(B)

10 ft

(C)

15 ft

(D)

20 ft
32.

A wood processing plant installed a waste gas scrubber at a cost of $30,000 to remove pollutants from the exhaust discharged into the atmosphere. The scrubber has no salvage value and will cost $18,700 to operate next year, with operating costs expected to increase at the rate of $1200 per year thereafter. Money can be borrowed at 12%. Approximately when should the company consider replacing the scrubber?

(A)

3 yr

(B)

6 yr

(C)

8 yr

(D)

10 yr

33.

Two alternative piping schemes are being considered by a water treatment facility. Head and horsepower are reflected in the hourly cost of operation. On the basis of a 10-year life and an interest rate of 12%, what is most nearly the number of hours of operation for which the two installations will be equivalent?

	alternative A	alternative B
pipe diameter	4 in	6 in

	alternative A	alternative B
head loss for required flow	48 ft	26 ft
size motor required	20 hp	7 hp
energy cost per hour of operation	$0.30	$0.10
cost of motor installed	$3600	$2800
cost of pipes and fittings	$3050	$5010
salvage value at end of 10 years	$200	$280

(A)

1000 hr

(B)

3000 hr

(C)

5000 hr

(D)

6000 hr
34.

A company is considering two alternatives, only one of which can be selected.

alternative	initial investment	salvage value	annual net profit	life
A	$120,000	$15,000	$57,000	5 yr
B	$170,000	$20,000	$67,000	5 yr

The net profit is after operating and maintenance costs, but before taxes. The company pays 45% of its year-end profit as income taxes. Use straight line depreciation. Do not use investment tax credit. Determine whether each alternative has an ROR greater than the MARR.

(A)

Alternative A has ROR > MARR.

(B)

Alternative B has ROR > MARR.

(C)

Both alternatives have ROR > MARR.

(D)

Neither alternative has ROR > MARR.

35.

A company is considering the purchase of equipment to expand its capacity. The equipment cost is $300,000. The equipment is needed for five years, after which it will be sold for $50,000. The company's before-tax cash flow will be improved $90,000 annually by the purchase of the asset. The corporate tax rate is 48%, and straight line depreciation will be used. The company will take an investment tax credit of 6.67%. What is the after-tax rate of return associated with this equipment purchase?

(A)

10.9%

(B)

11.8%

(C)

12.2%

(D)

13.2%
36.

A 120-room hotel is purchased for $2,500,000. A 25-year loan is available for 12%. The year-end convention applies to loan payments. A study was conducted to determine the various occupancy rates.

occupancy	probability
65% full	0.40
70%	0.30
75%	0.20
80%	0.10

The operating costs of the hotel are as follows.

taxes and insurance	$20,000 annually
maintenance	$50,000 annually
operating	$200,000 annually

The life of the hotel is figured to be 25 years when operating 365 days per year. The salvage value after 25 years is $500,000. The new hotel owners want to receive an annual rate of return of 15% on their investment. Neglect tax credit and income taxes. The average rate that should be charged per room per night is most nearly

(A)

$27

(B)

$29

(C)

$30

(D)

$31

37.

A company is insured for $3,500,000 against fire and the insurance rate is $0.69/$1000. The insurance company will decrease the rate to $0.47/$1000 if fire sprinklers are installed. The initial cost of the sprinklers is $7500.

Annual costs are $200; additional taxes are $100 annually. The system life is 25 years. The rate of return is most nearly

(A)

3.8%

(B)

5.0%

(C)

13%

(D)

16%
38.

Heat losses through the walls in an existing building cost a company $1,300,000 per year. This amount is considered excessive, and two alternatives are being evaluated. Neither of the alternatives will increase the life of the existing building beyond the current expected life of six years, and neither of the alternatives will produce a salvage value. Improvements can be depreciated.

Alternative A: Do nothing, and continue with current losses.

Alternative B: Spend $2,000,000 immediately to upgrade the building and reduce the loss by 80%. Annual maintenance will cost $150,000.

Alternative C: Spend $1,200,000 immediately. Then, repeat the $1,200,000 expenditure 3 years from now. Heat loss the first year will be reduced 80%. Due to deterioration, the reduction will be 55% and 20% in the second and third years. (The pattern is repeated starting after the second expenditure.) There are no maintenance costs.

All energy and maintenance costs are considered expenses for tax purposes. The company's tax rate is 48%, and straight line depreciation is used. 15% is regarded as the effective annual interest rate. Evaluate each alternative on an after-tax basis. Which alternative should be recommended?

(A)

alternative A

(B)

alternative B

(C)

alternative C

(D)

not enough information

39.

You have been asked to determine if a seven-year-old machine should be replaced. Base your decision on a before-tax interest rate of 15%.

The existing machine is presumed to have a 10-year life. It has been depreciated on a straight line basis from its original value of $1,250,000 to a current book value of $620,000. Its ultimate salvage value was assumed to be $350,000 for purposes of depreciation. Its present salvage value is estimated at $400,000, and this is not expected to change over the next three years. The current operating costs are not expected to change from $200,000 per year.

A new machine costs $800,000, with operating costs of $40,000 the first year, and increasing by $30,000 each year thereafter. The new machine has an expected life of 10 years. The salvage value depends on the year the new machine is retired.

year retired	salvage
1	$600,000
2	$500,000
3	$450,000
4	$400,000
5	$350,000
6	$300,000
7	$250,000
8	$200,000
9	$150,000
10	$100,000

From an economic perspective, when does it makes sense to buy the new piece of equipment?

(A)

during years 1–3

(B)

during years 4–6

(C)

during years 7–10

(D)

never

40.

As production facilities move toward just-in-time manufacturing, it is important to minimize

(A)

demand rate

(B)

production rate

(C)

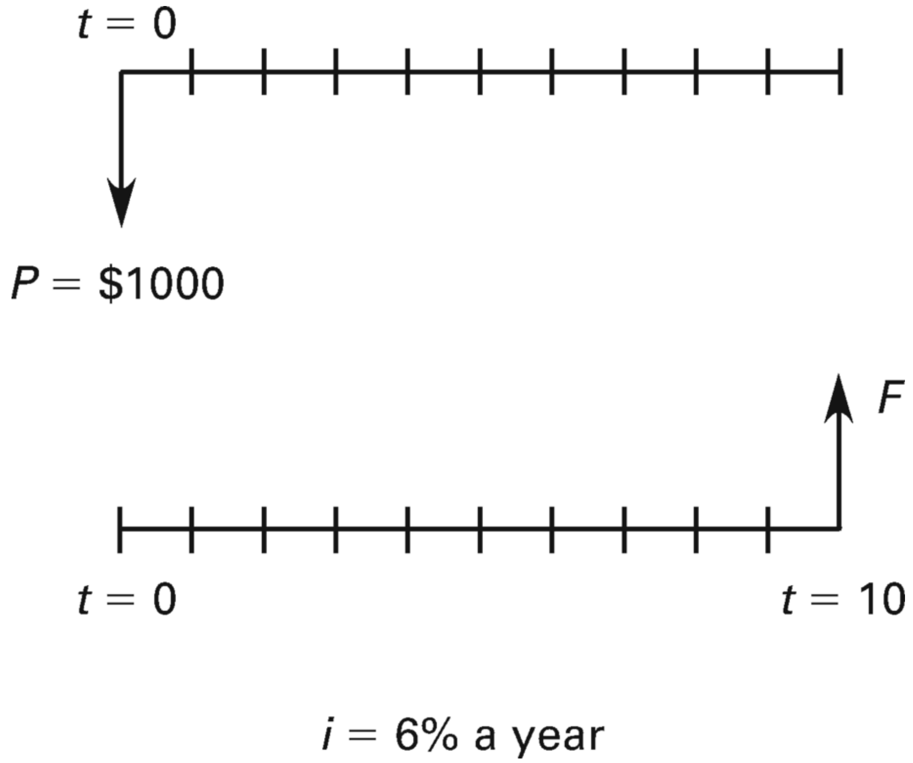
inventory carrying cost

(D)

setup cost

Solutions

1.



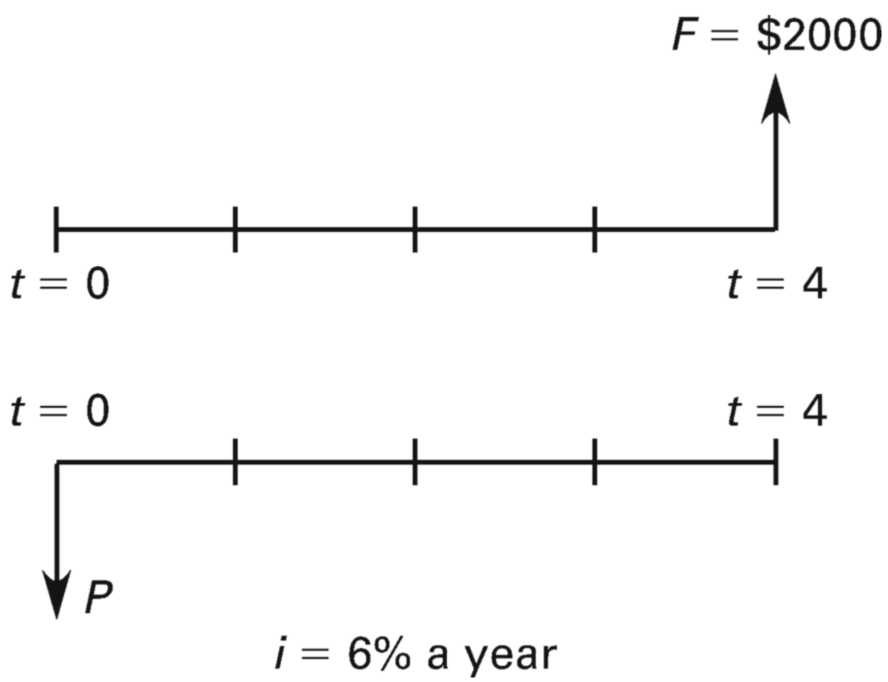
Using the formula from tableCERM86001 (also *NCEES Handbook:* Cost Estimation and Project Evaluation),

$$F = P(1+i)^n = (\$1000)\,(1+0.06)^{10}$$
$$= \$1790.85$$

Using the factor from appendixCERM87B (also *NCEES Handbook:* Cost Estimation and Project Evaluation), $(F/P, i\%, n) = 1.7908$ for $i = 6\%$ a year and $n = 10$ years.

$$F = P\,(F/P, 6\%, 10) = (\$1000)\,(1.7908)$$
$$= \$1790.80 \quad (\$1800)$$

The answer is (D).
2.



Using the formula from tableCERM86001 (also *NCEES Handbook:* Cost Estimation and Project Evaluation),

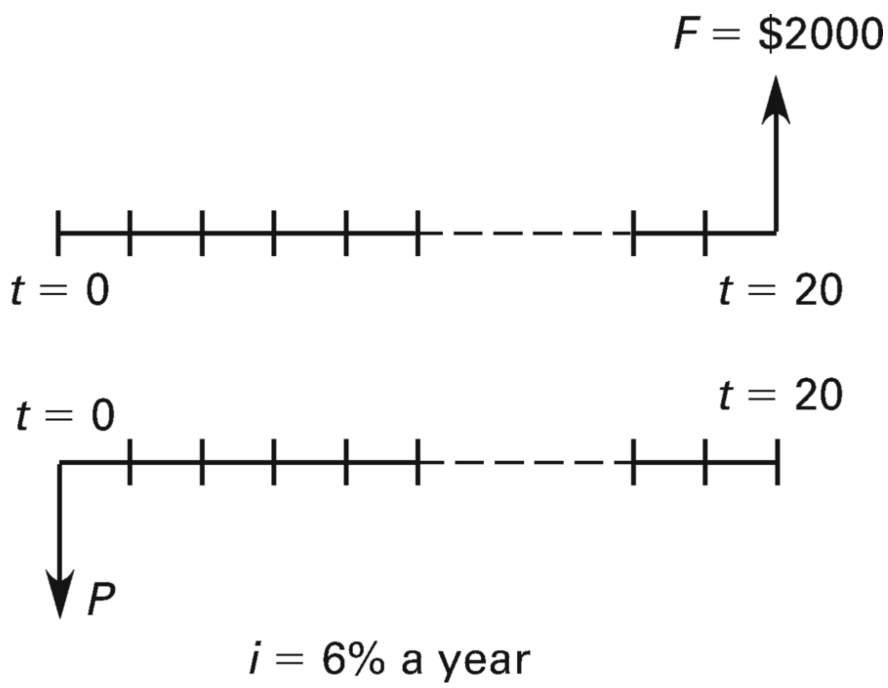
$$P = \frac{F}{(1+i)^n} = \frac{\$2000}{(1+0.06)^4}$$
$$= \$1584.19$$

Using the factor from appendixCERM87B (also *NCEES Handbook:* Cost Estimation and Project Evaluation), $(P/F, i, n) = 0.7921$ for $i = 6\%$ a year and $n = 4$ years.

$$P = F(P/F, 6\%, 4) = (\$2000)(0.7921)$$
$$= \$1584.20 \quad (\$1600)$$

The answer is (C).

3.



Using the formula from tableCERM86001 (also *NCEES Handbook:* Cost Estimation and Project Evaluation),

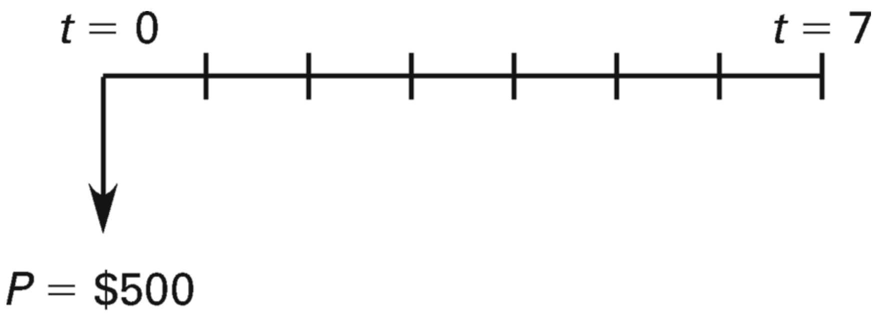
$$P = \frac{F}{(1+i)^n} = \frac{\$2000}{(1+0.06)^{20}}$$
$$= \$623.61$$

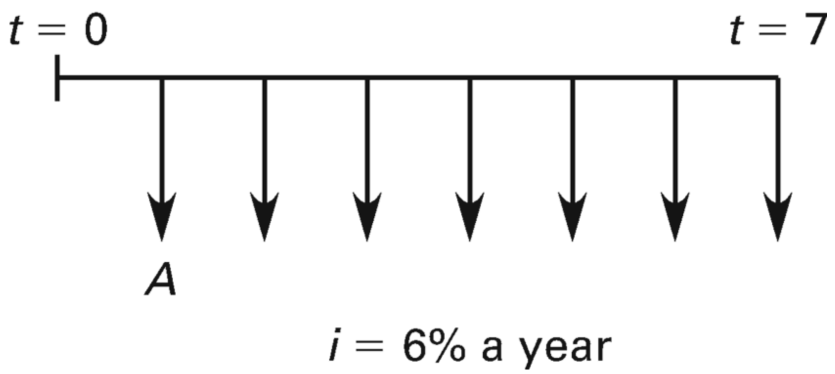
Using the factor from appendixCERM87B (also *NCEES Handbook:* Cost Estimation and Project Evaluation), $(P/F, i, n) = 0.3118$ for $i = 6\%$ a year and $n = 20$ years.

$$P = F(P/F, 6\%, 20) = (\$2000)(0.3118)$$
$$= \$623.60 \quad (\$620)$$

The answer is (A).

4.





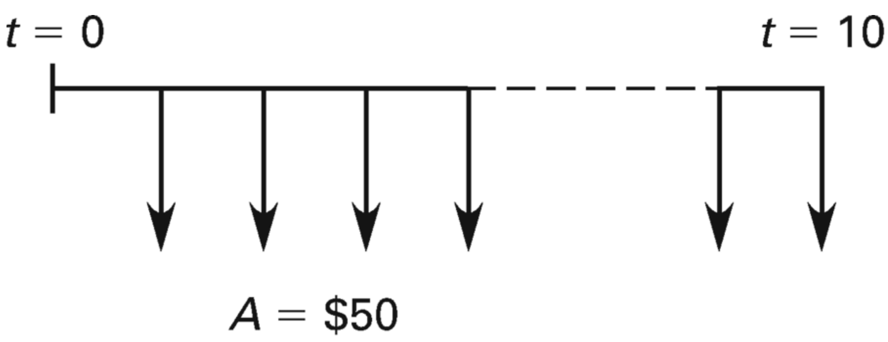
Using the formula from tableCERM86001 (also *NCEES Handbook:* Cost Estimation and Project Evaluation),

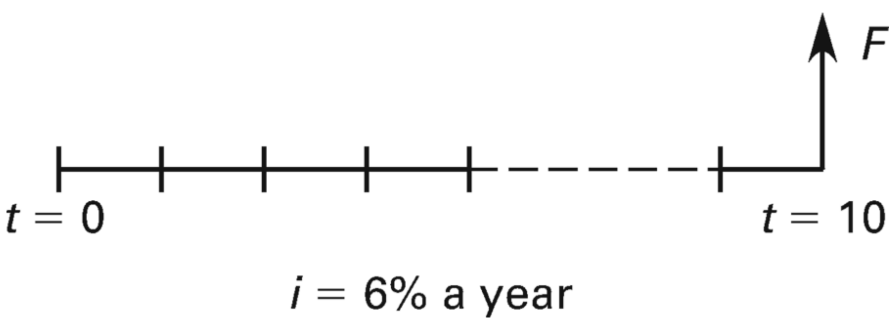
$$\begin{aligned} A &= P\left(\frac{i(1+i)^n}{(1+i)^n-1}\right) = (\$500)\left(\frac{(0.06)\,(1+0.06)^7}{(1+0.06)^7-1}\right) \\ &= \$89.57 \end{aligned}$$

Using the factor from appendixCERM87B (also *NCEES Handbook:* Cost Estimation and Project Evaluation), $(A/P, i, n) = 0.1791$ for $i = 6\%$ a year and $n = 7$ years.

$$\begin{aligned} A &= P\,(A/P, 6\%, 7) = (\$500)\,(0.17914) \\ &= \$89.55 \quad (\$90) \end{aligned}$$

The answer is (A).
5.





Using the formula from tableCERM86001 (also *NCEES Handbook:* Cost Estimation and Project Evaluation),

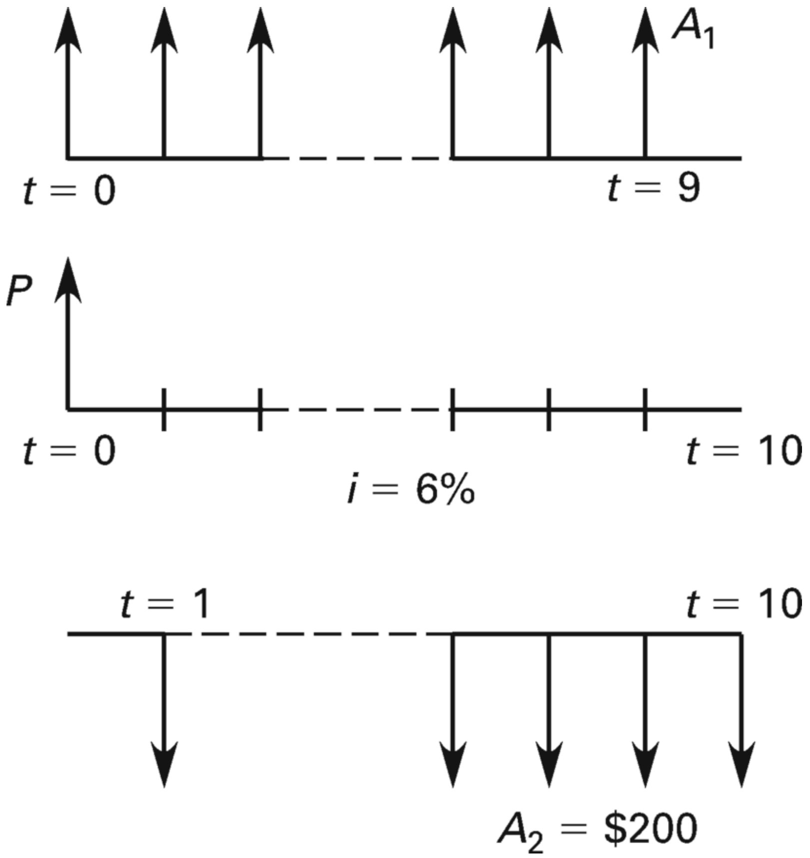
$$
\begin{aligned}
F &= A\left(\frac{(1+i)^n-1}{i}\right)\\
&= (\$50)\left(\frac{(1+0.06)^{10}-1}{0.06}\right)\\
&= \$659.04
\end{aligned}
$$

Using the factor from appendixCERM87B (also *NCEES Handbook:* Cost Estimation and Project Evaluation), $(F/A, i, n) = 13.1808$ for $i = 6\%$ a year and $n = 10$ years.

$$
\begin{aligned}
F &= A\,(F/A, 6\%, 10)\\
&= (\$50)\,(13.1808)\\
&= \$659.04 \quad (\$660)
\end{aligned}
$$

The answer is (C).

6.



From tableCERM86001 (also *NCEES Handbook:* Cost Estimation and Project Evaluation), for each cash flow diagram,

$$
\begin{aligned}
P &= A_1 + A_1\left(\frac{(1+0.06)^9-1}{(0.06)\,(1+0.06)^9}\right)\\
&= A_2\left(\frac{(1+0.06)^{10}-1}{(0.06)\,(1+0.06)^{10}}\right)
\end{aligned}
$$

Therefore, for $A_2 = \$200$,

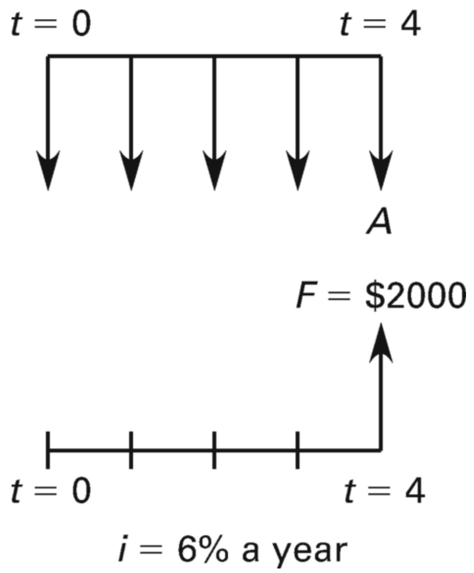
$$
\begin{aligned}
A_1 + A_1\left(\frac{(1+0.06)^9-1}{(0.06)\,(1+0.06)^9}\right) &= (\$200)\\
&\quad\times\left(\frac{(1+0.06)^{10}-1}{(0.06)\,(1+0.06)^{10}}\right)\\
7.80A_1 &= \$1472.02\\
A_1 &= \$188.72
\end{aligned}
$$

Using factors from appendixCERM87B (also *NCEES Handbook:* Cost Estimation and Project Evaluation),

$$\begin{aligned}(P/A, 6\%, 9) &= 6.8017\\ (P/A, 6\%, 10) &= 7.3601\\ A_1 + A_1(6.8017) &= (\$200)(7.3601)\\ 7.8017A_1 &= \$1472.02\\ A_1 &= \frac{\$1472.02}{7.8017}\\ &= \$188.68 \quad (\$190)\end{aligned}$$

The answer is (A).

7.



From tableCERM86001 (also *NCEES Handbook:* Cost Estimation and Project Evaluation),

$$F = A\left(\frac{(1+i)^n - 1}{i}\right)$$

Since the deposits start at the beginning of each year, five deposits are made that contribute to the final amount. This is equivalent to a cash flow that starts at $t = -1$ without a deposit and has a duration (starting at $t = -1$) of five years.

$$\begin{aligned}F &= A\left(\frac{(1+i)^n - 1}{i}\right) = \$2000\\ &= A\left(\frac{(1+0.06)^5 - 1}{0.06}\right)\end{aligned}$$

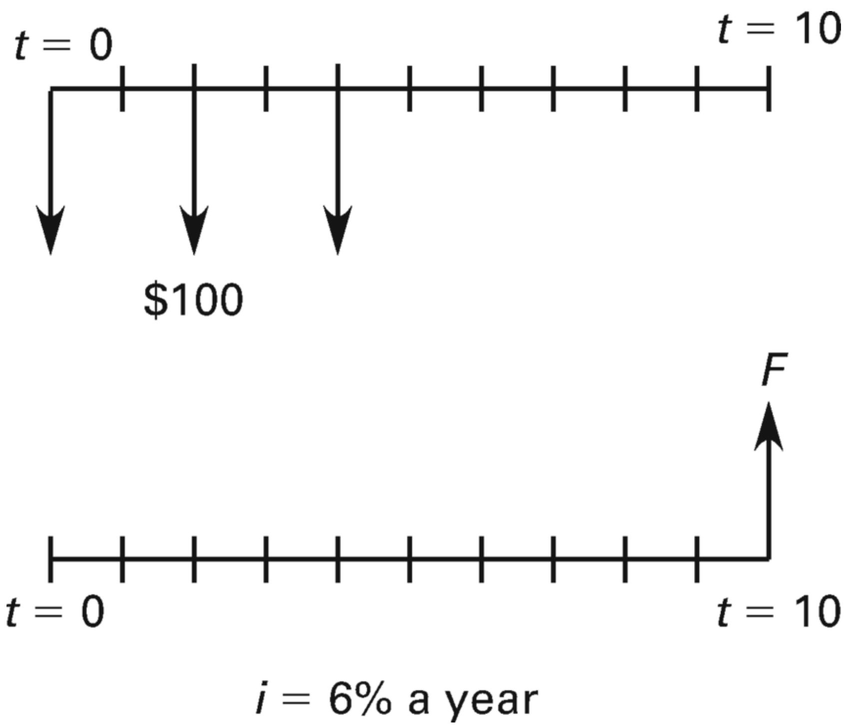
$$\begin{aligned}\$2000 &= 5.6371A\\ A &= \frac{\$2000}{5.6371}\\ &= \$354.79\end{aligned}$$

Using factors from appendixCERM87B (also *NCEES Handbook:* Cost Estimation and Project Evaluation),

$$\begin{aligned}F &= A\big((F/P, 6\%, 4) + (F/A, 6\%, 4)\big)\\ \$2000 &= A(1.2625 + 4.3746)\\ A &= \$354.79 \quad (\$350)\end{aligned}$$

The answer is (A).

8.



From tableCERM86001 (also *NCEES Handbook:* Cost Estimation and Project Evaluation), $F = P(1 + i)^n$. If each deposit is considered as P, each will accumulate interest for periods of 10, 8, and 6 years. Therefore,

$$\begin{aligned} F &= (\$100)\left(1+0.06\right)^{10} + (\$100)\left(1+0.06\right)^{8} \\ &\quad + (\$100)\left(1+0.06\right)^{6} \\ &= (\$100)\,(1.7908 + 1.5938 + 1.4185) \\ &= \$480.31 \end{aligned}$$

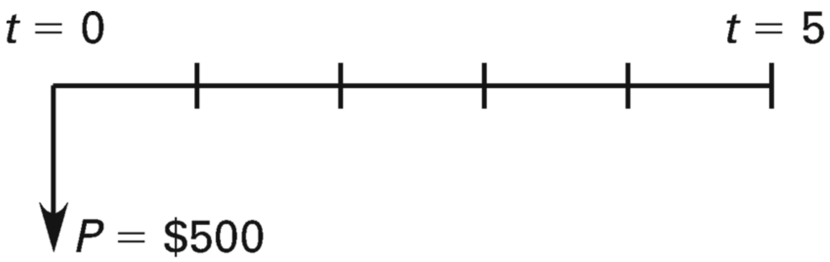
Using appendixCERM87B (also *NCEES Handbook:* Cost Estimation and Project Evaluation),

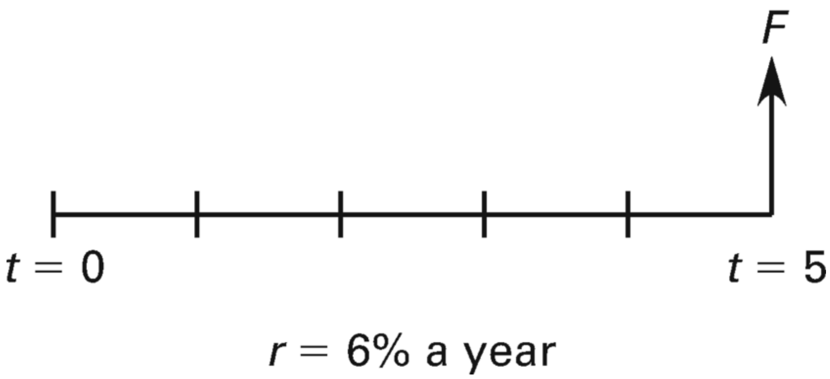
$$\begin{aligned} (F/P, i, n) &= 1.7908 \text{ for } i = 6\% \text{ and } n = 10 \\ &= 1.5938 \text{ for } i = 6\% \text{ and } n = 8 \\ &= 1.4185 \text{ for } i = 6\% \text{ and } n = 6 \end{aligned}$$

By summation,

$$\begin{aligned} F &= (\$100)\,(1.7908 + 1.5938 + 1.4185) \\ &= \$480.31 \quad (\$480) \end{aligned}$$

The answer is (B).
9.





Since the deposit is compounded monthly, the effective interest rate should be calculated from equationCERM86054 (also *NCEES Handbook:* Cost Estimation and Project Evaluation).

$$\begin{aligned} i &= \left(1+\frac{r}{k}\right)^k - 1 = \left(1+\frac{0.06}{12}\right)^{12} - 1 \\ &= 0.061678 \end{aligned}$$

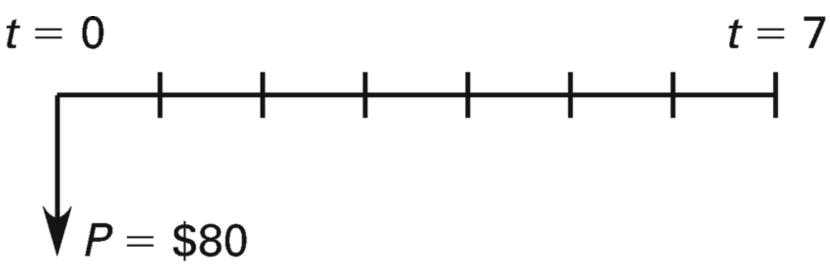
From tableCERM86001 (also *NCEES Handbook:* Cost Estimation and Project Evaluation),

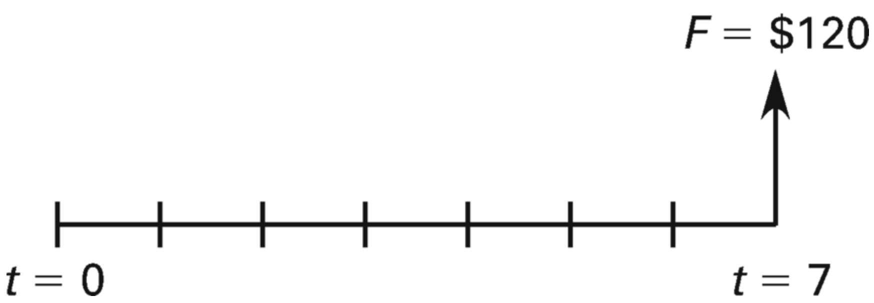
$$\begin{aligned} F &= P(1+i)^n = (\$500)\,(1+0.061678)^5 \\ &= \$674.43 \end{aligned}$$

Use *NCEES Handbook:* Cost Estimation and Project Evaluation.

$$\begin{aligned} F &= P\,(F/P, 6.1678\%, 5) = (\$500)\,(1.3490) \\ &= \$674.50 \quad (\$675) \end{aligned}$$

The answer is (C).
10.





From tableCERM86001 (also *NCEES Handbook:* Cost Estimation and Project Evaluation),

$$F = P(1+i)^n$$

Therefore,

$$(1+i)^n = F/P$$

$$i = (F/P)^{1/n} - 1 = \left(\frac{\$120}{\$80}\right)^{1/7} - 1$$
$$= 0.0596 \approx 6.0\%$$

From tableCERM86001 (also *NCEES Handbook:* Cost Estimation and Project Evaluation),

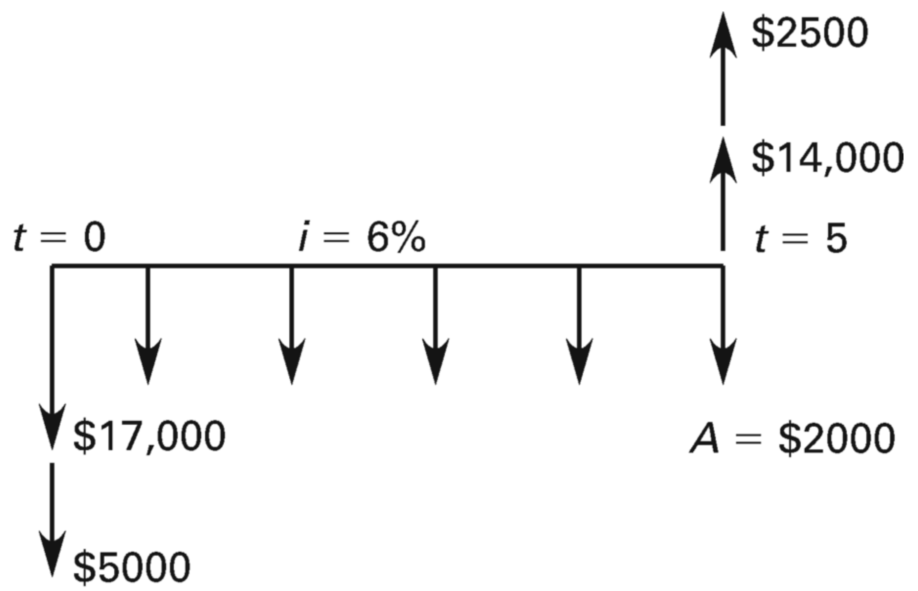
$$F = P\,(F/P, i\%, 7)$$
$$(F/P, i\%, 7) = F/P = \frac{\$120}{\$80} = 1.5$$

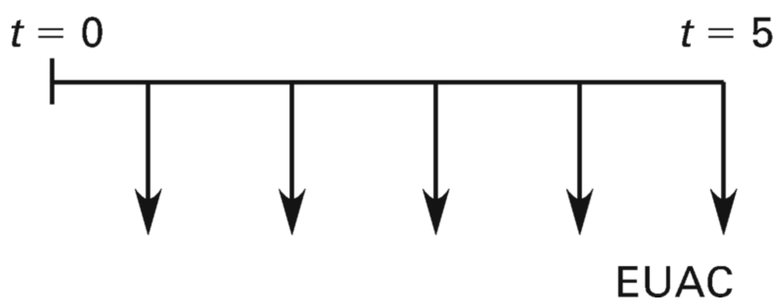
From appendixCERM87B (also *NCEES Handbook:* Cost Estimation and Project Evaluation),

$$(F/P, i\%, 7) = 1.4071 \text{ for } i = 5\%$$
$$= 1.5036 \text{ for } i = 6\%$$
$$= 1.6058 \text{ for } i = 7\%$$

Therefore, $i \approx 6.0\%$.

The answer is (D).
11.



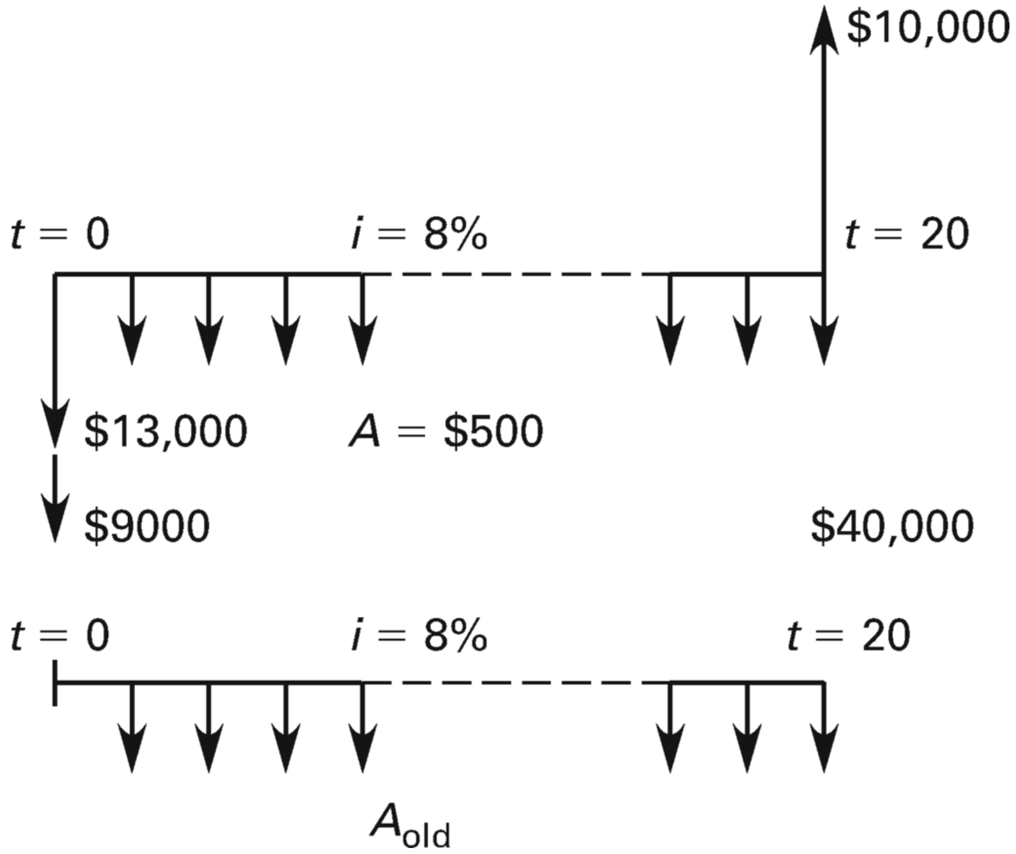


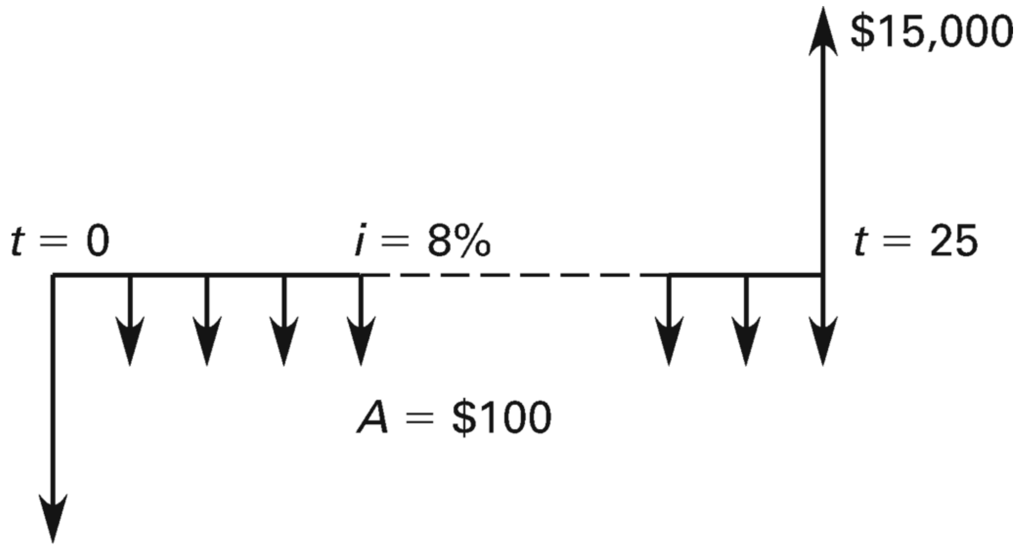
As in *NCEES Handbook:* Cost Estimation and Project Evaluation, annual cost of ownership, EUAC, can be obtained by the factors converting P to A and F to A.

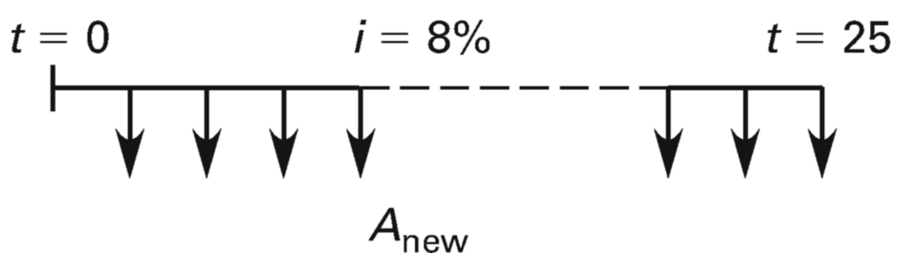
$$
\begin{aligned}
P &= \$17{,}000 + \$5000 \\
&= \$22{,}000 \\
F &= \$14{,}000 + \$2500 \\
&= \$16{,}500 \\
\text{EUAC} &= A + P\,(A/P, 6\%, 5) - F\,(A/F, 6\%, 5) \\
(A/P, 6\%, 5) &= 0.2374 \\
(A/F, 6\%, 5) &= 0.1774 \\
\text{EUAC} &= \$2000 + (\$22{,}000)\,(0.2374) \\
&\quad - (\$16{,}500)\,(0.1774) \\
&= \$4295.70 \quad (\$4300)
\end{aligned}
$$

The answer is (C).

12.







Consider the salvage value as a benefit lost (cost).

$$\begin{aligned}
\text{EUAC}_{\text{old}} &= \$500 + (\$9000 + \$13{,}000)\,(A/P, 8\%, 20) \\
&\quad - (\$10{,}000)\,(A/F, 8\%, 20) \\
(A/P, 8\%, 20) &= 0.1019 \\
(A/F, 8\%, 20) &= 0.0219 \\
\text{EUAC}_{\text{old}} &= \$500 + (\$22{,}000)\,(0.1019) \\
&\quad - (\$10{,}000)\,(0.0219) \\
&= \$2522.80
\end{aligned}$$

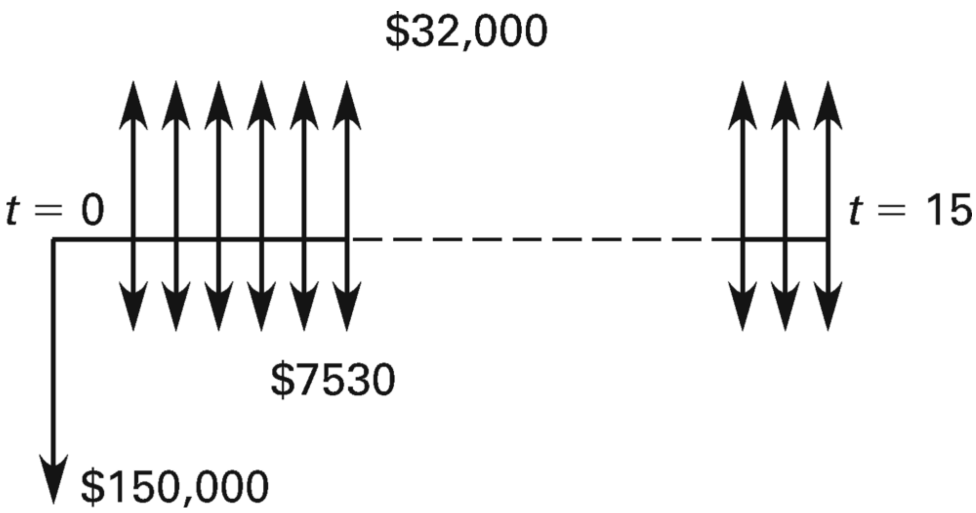
Similarly,

$$\begin{aligned}
\text{EUAC}_{\text{new}} &= \$100 + (\$40{,}000)\,(A/P, 8\%, 25) \\
&\quad - (\$15{,}000)\,(A/F, 8\%, 25) \\
(A/P, 8\%, 25) &= 0.0937 \\
(A/F, 8\%, 25) &= 0.0137 \\
\text{EUAC}_{\text{new}} &= \$100 + (\$40{,}000)\,(0.0937) \\
&\quad - (\$15{,}000)\,(0.0137) \\
&= \$3642.50
\end{aligned}$$

Therefore, the new bridge is more costly.

The best alternative is to strengthen the old bridge.

The answer is (A).
13.



As in *NCEES Handbook* table "Depreciation Methods," the annual depreciation is

$$D = \frac{C - S_n}{n} = \frac{\$150{,}000}{15} = \$10{,}000/\text{year}$$

The taxable income is

$$\$32{,}000 - \$7530 - \$10{,}000 = \$14{,}470/\text{year}$$

Taxes paid are

$$(\$14{,}470)\,(0.48) = \$6945.60/\text{year}$$

The after-tax cash flow is

$$\$32{,}000 - \$7530 - \$6945.60 = \$17{,}524.40$$

The present worth of the alternate is zero when evaluated at its ROR.

$$0 = -\$150{,}000 + (\$17{,}524.40)\,(P/A, i\%, 15)$$

Therefore,

$$(P/A, i\%, 15) = \frac{\$150{,}000}{\$17{,}524.40} = 8.55949$$

From appendixCERM87B, this factor matches $i = 8\%$.

$$\text{ROR} = 8.0\%$$

The answer is (A).
14.

The conventional benefit/cost ratio is

$$B/C = \frac{B - D}{C}$$

The benefit/cost ratio will be

$$B/C = \frac{\$1{,}500{,}000 - \$300{,}000}{\$1{,}000{,}000} = 1.2$$

The excess of benefits over cost is $\$200{,}000$.

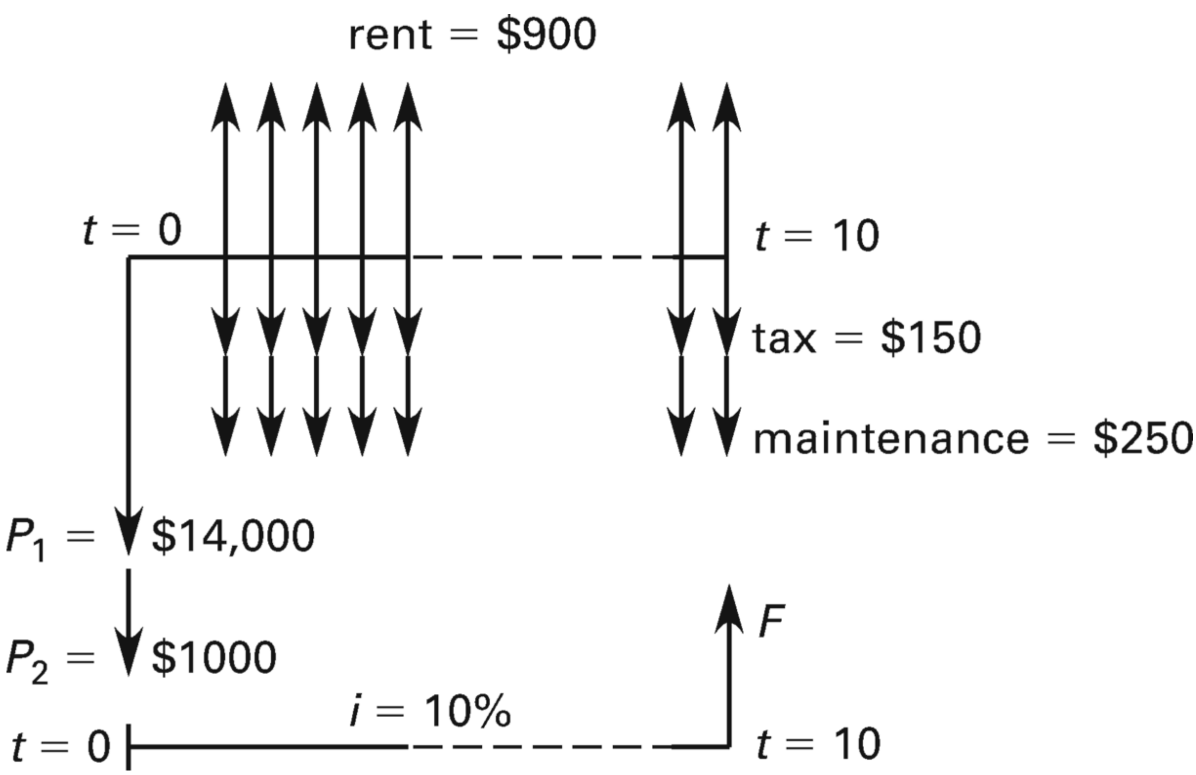
The answer is (A).

15.

The annual rent is

$$(\$75)\left(12\ \frac{\text{months}}{\text{year}}\right) = \$900$$

$$\begin{aligned} P &= P_1 + P_2 = \$15{,}000 \\ A_1 &= -\$900 \\ A_2 &= \$250 + \$150 = \$400 \end{aligned}$$

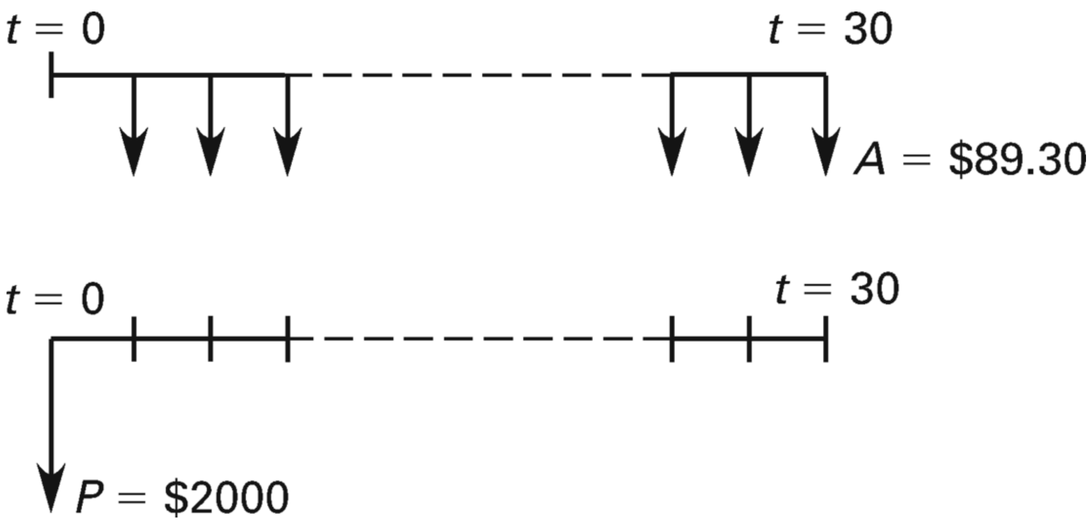


From tableCERM86001 (also *NCEES Handbook:* Cost Estimation and Project Evaluation),

$$\begin{aligned} F &= (\$15{,}000)\,(F/P, 10\%, 10) \\ &\quad + (\$400)\,(F/A, 10\%, 10) \\ &\quad - (\$900)\,(F/A, 10\%, 10) \\ (F/P, 10\%, 10) &= 2.5937 \\ (F/A, 10\%, 10) &= 15.9374 \\ F &= (\$15{,}000)\,(2.5937) + (\$400)\,(15.9374) \\ &\quad - (\$900)\,(15.9374) \\ &= \$30{,}937 \quad (\$31{,}000) \end{aligned}$$

The answer is (B).

16.



From tableCERM86001 (also *NCEES Handbook:* Cost Estimation and Project Evaluation),

$$P = A\left(\frac{(1+i)^n - 1}{i(1+i)^n}\right)$$

$$\frac{(1+i)^{30} - 1}{i(1+i)^{30}} = \frac{\$2000}{\$89.30} = 22.40$$

By trial and error,

$i\%$	$(1+i)^{30}$	$\frac{(1+i)^{30}-1}{i(1+i)^{30}}$
10	17.45	9.43
6	5.74	13.76
4	3.24	17.29
2	1.81	22.40

2% per month is close.

$$\begin{aligned} i &= (1+0.02)^{12} - 1 \\ &= 0.2682 \quad (27\%) \end{aligned}$$

The answer is (A).

17.

Use the straight line method, from equationCERM86025 (also *NCEES Handbook:* Cost Estimation and Project Evaluation).

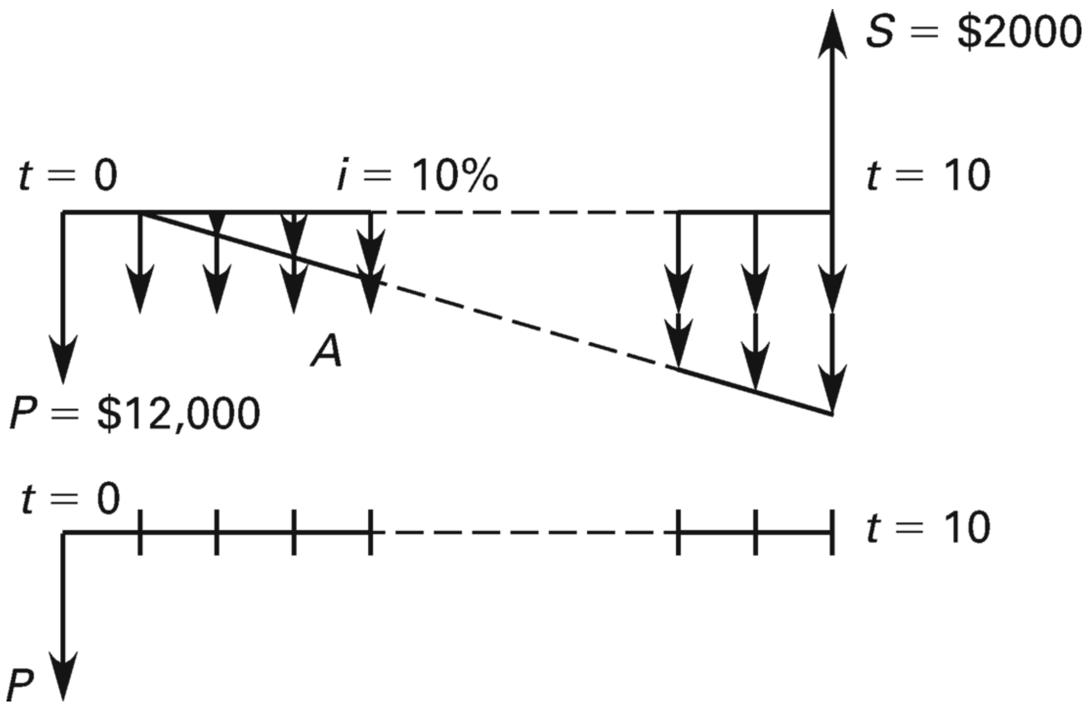
$$D = \frac{C - S_n}{n}$$

Each year depreciation will be the same.

$$D = \frac{\$500{,}000 - \$100{,}000}{25} = \$16{,}000$$

The answer is (B).

18.



A is \$1000 for t = 10 years, and G is \$200 for $t = n - 1 = 9$ years. With a future value F = the sale value S = \$2,000, the present worth (cost) is

$$\begin{aligned} P &= \$12{,}000 + A\,(P/A, 10\%, 10) + G\,(P/G, 10\%, 9) \\ &\quad - F\,(P/F, 10\%, 10) \\ &= \$12{,}000 + (\$1000)\,(6.1446) + (\$200)\,(19.4215) \\ &\quad - (\$2000)\,(0.3855) \\ &= \$21{,}258 \quad (\$21{,}000) \end{aligned}$$

The answer is (C).

19.

An increase in rock removal capacity can be achieved by a 20-year loan (investment). Different cases can be compared by equivalent uniform annual cost (EUAC).

$$\begin{aligned} \text{EUAC} &= \text{annual loan cost} \\ &\quad + \text{expected annual damage} \\ &= \text{cost}\ (A/P, 10\%, 20) \\ &\quad + (\$25{,}000)\,(\text{probability}) \\ (A/P, 10\%, 20) &= 0.1175 \end{aligned}$$

A table can be prepared for different cases.

rock removal rate	cost ($)	annual loan cost ($)	expected annual damage ($)	EUAC ($)
7	0	0	3750	3750.00
8	15,000	1761.90	2500	4261.90
9	20,000	2349.20	1750	4099.20
10	30,000	3523.80	750	4273.80

It is cheapest to do nothing.

The answer is (A).

20.

Calculate the cost of owning and operating for years one and two using *NCEES Handbook:* Cost Estimation and Project Evaluation.

$$\begin{aligned} A_1 &= (\$10{,}000)\,(A/P, 20\%, 1) + \$2000 \\ &\quad - (\$8000)\,(A/F, 20\%, 1) \\ (A/P, 20\%, 1) &= 1.2 \\ (A/F, 20\%, 1) &= 1.0 \\ A_1 &= (\$10{,}000)\,(1.2) + \$2000 - (\$8000)\,(1.0) \\ &= \$6000 \\ A_2 &= (\$10{,}000)\,(A/P, 20\%, 2) + \$2000 \\ &\quad + (\$1000)\,(A/G, 20\%, 2) \\ &\quad - (\$7000)\,(A/F, 20\%, 2) \\ (A/P, 20\%, 2) &= 0.6545 \\ (A/G, 20\%, 2) &= 0.4545 \\ (A/F, 20\%, 2) &= 0.4545 \\ A_2 &= (\$10{,}000)\,(0.6545) + \$2000 \\ &\quad + (\$1000)\,(0.4545) - (\$7000)\,(0.4545) \\ &= \$5818 \end{aligned}$$

Calculate the cost of owning and operating for years three through five using *NCEES Handbook:* Cost Estimation and Project Evaluation.

$$
\begin{aligned}
A_3 &= (\$10{,}000)\,(A/P, 20\%, 3) + \$2000 \\
&\quad + (\$1000)\,(A/G, 20\%, 3) \\
&\quad - (\$6000)\,(A/F, 20\%, 3) \\
(A/P, 20\%, 3) &= 0.4747 \\
(A/G, 20\%, 3) &= 0.8791 \\
(A/F, 20\%, 3) &= 0.2747 \\
A_3 &= (\$10{,}000)\,(0.4747) + \$2000 \\
&\quad + (\$1000)\,(0.8791) \\
&\quad - (\$6000)\,(0.2747) \\
&= \$5977.90 \\
A_4 &= (\$10{,}000)\,(A/P, 20\%, 4) \\
&\quad + \$2000 + (\$1000)\,(A/G, 20\%, 4) \\
&\quad - (\$5000)\,(A/F, 20\%, 4) \\
(A/F, 20\%, 4) &= 0.3863 \\
(A/F, 20\%, 4) &= 1.2742 \\
(A/F, 20\%, 4) &= 0.1863 \\
A_4 &= (\$10{,}000)\,(0.3863) + \$2000 \\
&\quad + (\$1000)\,(1.2742) - (\$5000)\,(0.1863) \\
&= \$6205.70
\end{aligned}
$$

$$
\begin{aligned}
A_5 &= (\$10{,}000)\,(A/P, 20\%, 5) + \$2000 \\
&\quad + (\$1000)\,(A/G, 20\%, 5) \\
&\quad - (\$4000)\,(A/F, 20\%, 5) \\
(A/P, 20\%, 5) &= 0.3344 \\
(A/G, 20\%, 5) &= 1.6405 \\
(A/F, 20\%, 5) &= 0.1344 \\
A_5 &= (\$10{,}000)\,(0.3344) + \$2000 \\
&\quad + (\$1000)\,(1.6405) \\
&\quad - (\$4000)\,(0.1344) \\
&= \$6446.90
\end{aligned}
$$

Since the annual owning and operating cost is smallest after two years of operation, it is advantageous to sell the mechanism after the second year.

The economic life is two years.

The answer is (B).

21.

To find out if the reimbursement is adequate, calculate the business-related expense as in *NCEES Handbook:* Cost Estimation and Project Evaluation.

Charge the company for business travel.

$$
\begin{aligned}
\text{insurance: } & \$3000 - \$2000 = \$1000 \\
\text{maintenance: } & \$2000 - \$1500 = \$500 \\
\text{drop in salvage value: } & \$10{,}000 - \$5000 = \$5000
\end{aligned}
$$

The annual portion of the drop in salvage value is

$$
\begin{aligned}
A &= (\$5000)\,(A/F, 10\%, 5) \\
(A/F, 10\%, 5) &= 0.1638 \\
A &= (\$5000)\,(0.1638) \\
&= \$819/\text{yr}
\end{aligned}
$$

The annual cost of gas is

$$\left(\frac{50{,}000 \text{ mi}}{15\ \dfrac{\text{mi}}{\text{gal}}}\right)\left(\frac{\$1.50}{\text{gal}}\right) = \$5000$$

$$\begin{aligned}\text{EUAC per mile} &= \frac{\$1000 + \$500 + \$819 + \$5000}{50{,}000 \text{ mi}} \\ &= \$0.14638/\text{mi}\end{aligned}$$

Since the reimbursement per mile is \$0.30 and since $\$0.30 > \$0.14638$, the reimbursement is adequate.

Determine (with reimbursement) how many miles the car must be driven to break even.

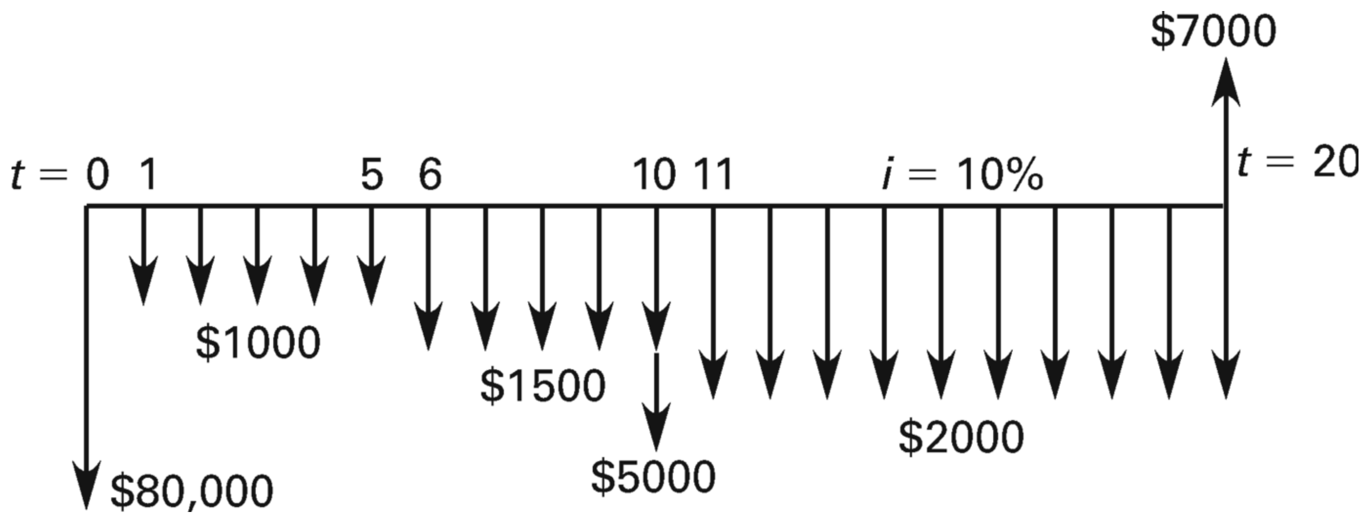
If the car is driven *M* miles per year,

$$\begin{aligned}\left(\frac{\$0.30}{1 \text{ mi}}\right) M &= (\$50{,}000)\,(A/P, 10\%, 5) + \$2500 \\ &\quad + \$2000 - (\$8000)\,(A/F, 10\%, 5) \\ &\quad + \left(\frac{M}{15\ \dfrac{\text{mi}}{\text{gal}}}\right)(\$1.50)\end{aligned}$$

$$\begin{aligned}(A/P, 10\%, 5) &= 0.2638 \\ (A/F, 10\%, 5) &= 0.1638 \\ 0.3M &= (\$50{,}000)\,(0.2638) + \$2500 + \$2000 \\ &\quad - (\$8000)\,(0.1638) + 0.1M \\ 0.2M &= \$16{,}379.60 \\ M &= \frac{\$16{,}379.60}{\dfrac{\$0.20}{1 \text{ mi}}} \\ &= 81{,}898 \text{ mi} \quad (82{,}000 \text{ mi})\end{aligned}$$

The answer is (C).
22.

Using *NCEES Handbook:* Cost Estimation and Project Evaluation, the present worth of alternative A is



$$\begin{aligned}P_A &= \$80{,}000 + (\$1000) \\ &\quad (P/A, 10\%, 5) + (\$1500) \\ &\quad (P/A, 10\%, 5)\,(P/F, 10\%, 5) \\ &\quad + (\$2000)\,(P/A, 10\%, 10) \\ &\quad + (\$5000)\,(P/F, 10\%, 10) \\ &\quad - (\$7000)\,(P/F, 10\%, 20)\end{aligned}$$

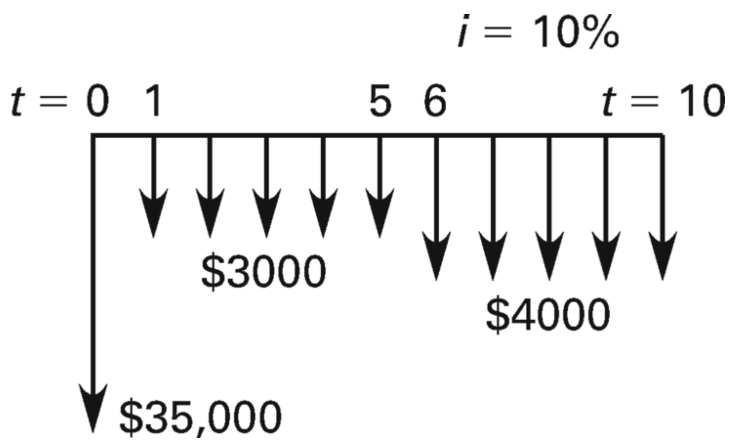
$$
\begin{aligned}
(P/A, 10\%, 5) &= 3.7908 \\
(P/F, 10\%, 5) &= 0.6209 \\
(P/A, 10\%, 10) &= 6.1446 \\
(P/F, 10\%, 10) &= 0.3855 \\
(P/F, 10\%, 20) &= 0.1486
\end{aligned}
$$

$$
\begin{aligned}
P_{\mathrm{A}} &= \$80{,}000 + (\$1000)(3.7908) \\
&\quad + (\$1500)(3.7908)(0.6209) \\
&\quad + (\$2000)(6.1446)(0.3855) \\
&\quad + (\$5000)(0.3855) \\
&\quad - (\$7000)(0.1486) \\
&= \$92{,}946.15
\end{aligned}
$$

Since the lives are different, compare by EUAC.

$$
\begin{aligned}
\mathrm{EUAC}\,(\mathrm{A}) &= (\$92{,}946.14)\,(A/P, 10\%, 20) \\
&= (\$92{,}946.14)(0.1175) \\
&= \$10{,}921
\end{aligned}
$$

Evaluate alternative B.



$$
\begin{aligned}
P_{\mathrm{B}} &= \$35{,}000 + (\$3000)\,(P/A, 10\%, 5) \\
&\quad + (\$4000)\,(P/A, 10\%, 5)\,(P/F, 10\%, 5) \\
(P/A, 10\%, 5) &= 3.7908 \\
(P/F, 10\%, 5) &= 0.6209 \\
P_{\mathrm{B}} &= \$35{,}000 + (\$3000)(3.7908) \\
&\quad + (\$4000)(3.7908)(0.6209) \\
&= \$55{,}787.23
\end{aligned}
$$

Since the lives are different, compare by EUAC.

$$
\begin{aligned}
\mathrm{EUAC}\,(\mathrm{B}) &= (\$55{,}787.23)\,(A/P, 10\%, 10) \\
&= (\$55{,}787.23)(0.1627) \\
&= \$9077
\end{aligned}
$$

Since EUAC(B) < EUAC(A), Alternative B is economically superior.

The answer is (B).

23.

If the annual cost is compared with a total annual mileage of M, for plan A,

$$A_{\mathrm{A}} = \$0.25M$$

Use *NCEES Handbook:* Cost Estimation and Project Evaluation throughout the rest of the problem.

For plan B,

$$A_B = (\$30{,}000)\,(A/P, 10\%, 3) + \$0.14M$$
$$+\$500 - (\$7200)\,(A/F, 10\%, 3)$$
$$(A/P, 10\%, 3) = 0.4021$$
$$(A/F, 10\%, 3) = 0.3021$$
$$A_B = (\$30{,}000)\,(0.4021) + \$0.14M + \$500$$
$$- (\$7200)\,(0.3021)$$
$$= \$10{,}387.88 + \$0.14M$$

For an equal annual cost $A_A = A_B$,

$$\$0.25M = \$10{,}387.88 + \$0.14M$$
$$\$0.11M = \$10{,}387.88$$
$$M = 94{,}435 \quad (94{,}000)$$

An annual mileage would be $M = 94{,}000$ mi.

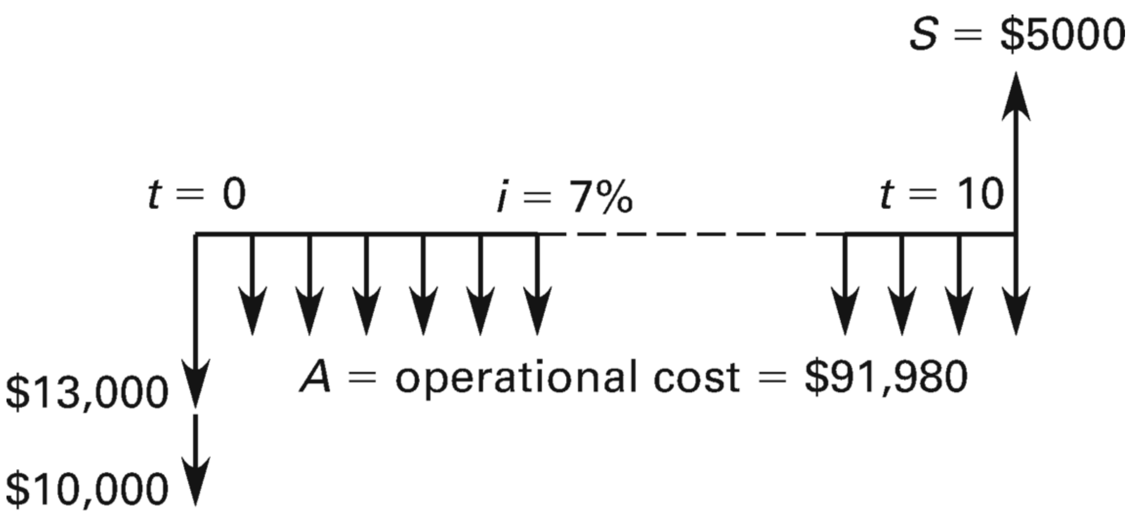
For an annual mileage less than that, $A_A < A_B$.

Plan A is economically superior until 94,000 mi is exceeded.

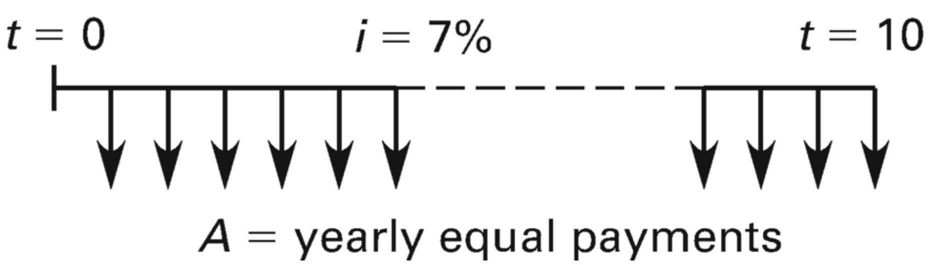
The answer is (A).
24.

Use *NCEES Handbook:* Cost Estimation and Project Evaluation.

Method A:



equivalent model



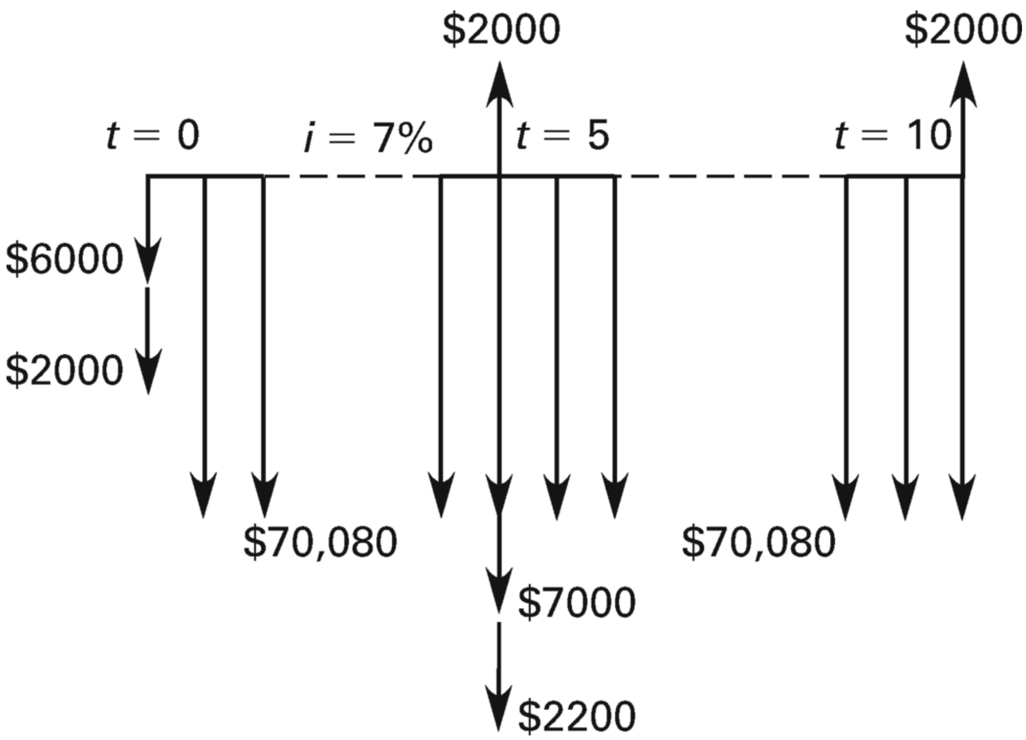
$$24 \text{ hr/day}$$
$$365 \text{ days/yr}$$
$$\text{total of } (24)\,(365) = 8760 \text{ hr/yr}$$
$$\$10.50 \text{ operational cost/hr}$$
$$\text{total of } (8760)\,(\$10.50) = \$91{,}980 \text{ operational cost/yr}$$

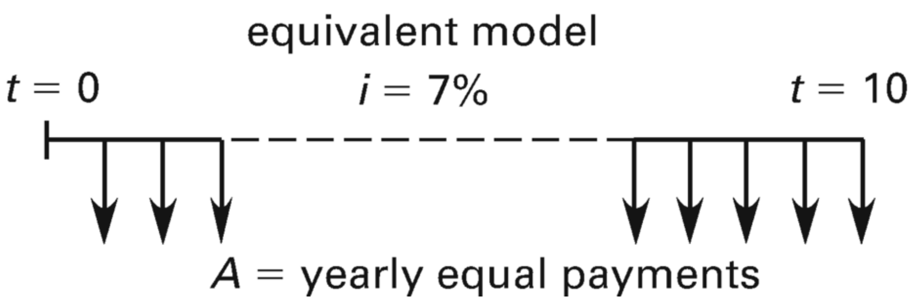
$$
\begin{aligned}
A &= \$91{,}980 + (\$23{,}000)\,(A/P, 7\%, 10) \\
&\quad - (\$5000)\,(A/F, 7\%, 10) \\
(A/P, 7\%, 10) &= 0.1424 \\
(A/F, 7\%, 10) &= 0.0724 \\
A &= \$91{,}980 + (\$23{,}000)\,(0.1424) \\
&\quad - (\$5000)\,(0.0724) \\
&= \$94{,}893.20/\text{yr}
\end{aligned}
$$

Therefore, the uniform annual cost per ton each year will be

$$
\frac{\$94{,}893.20}{50 \text{ ton}} = \$1897.86
$$

Method B:





$$
\begin{gathered}
8760 \text{ hr/yr} \\
\$8 \text{ operational cost/hr} \\
\text{total of } \$70{,}080 \text{ operational cost/yr}
\end{gathered}
$$

$$
\begin{aligned}
A = \$70{,}080 &+ (\$6000 + \$2000) \\
&\times (A/P, 7\%, 10) \\
&+ (\$7000 + \$2200 - \$2000) \\
&\times (P/F, 7\%, 5)\,(A/P, 7\%, 10) \\
&- (\$2000)\,(A/F, 7\%, 10)
\end{aligned}
$$

$$
\begin{aligned}
(A/P,7\%,10) &= 0.1424\\
(A/F,7\%,10) &= 0.0724\\
(P/F,7\%,5) &= 0.7130\\
A &= \$70{,}080 + (\$8000)(0.1424)\\
&\quad + (\$7200)(0.7130)(0.1424)\\
&\quad - (\$2000)(0.0724)\\
&= \$71{,}805.42/\text{yr}
\end{aligned}
$$

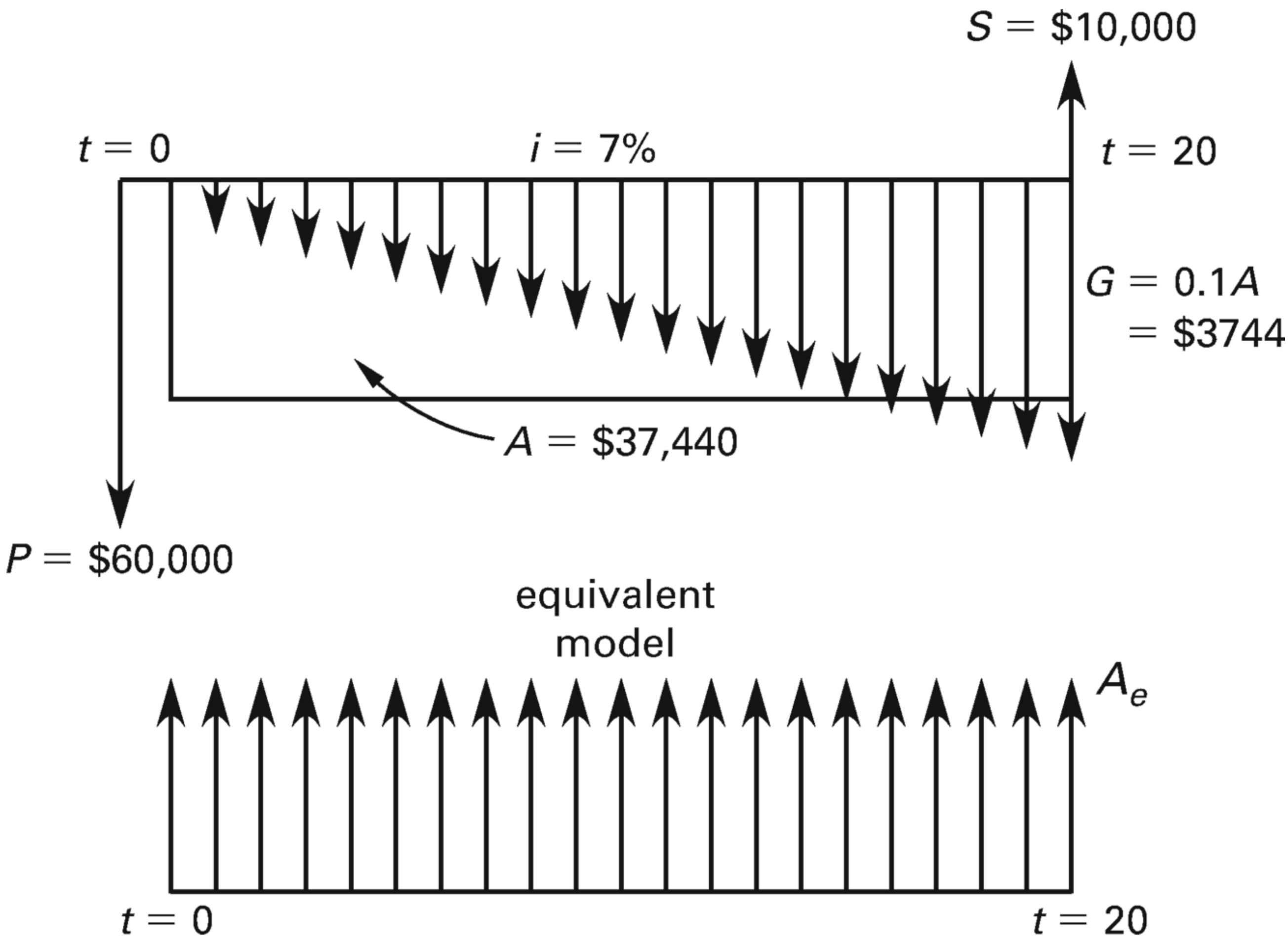
Therefore, the uniform annual cost per ton each year will be

$$
\frac{\$71{,}805.42}{20 \text{ ton}} = \$3590.27 \quad (\$3600)
$$

The answer is (B).
25.

As in *NCEES Handbook:* Cost Estimation and Project Evaluation,

$$
\begin{aligned}
A_e &= (\$60{,}000)(A/P,7\%,20) + A\\
&\quad + G(P/G,7\%,20)(A/P,7\%,20)\\
&\quad - (\$10{,}000)(A/F,7\%,20)\\
(A/P,7\%,20) &= 0.0944\\
A &= (37{,}440 \text{ mi})\left(\frac{\$1.0}{1 \text{ mi}}\right) = \$37{,}440\\
G &= 0.1A = (0.1)(\$37{,}440) = \$3744\\
(P/G,7\%,20) &= 77.5091\\
(A/F,7\%,20) &= 0.0244\\
A_e &= (\$60{,}000)(0.0944) + \$37{,}440\\
&\quad + (\$3744)(77.5091)(0.0944)\\
&\quad - (\$10{,}000)(0.0244)\\
&= \$70{,}254.32
\end{aligned}
$$



With 80,000 passengers a year, the break-even fare per passenger would be

$$\begin{aligned} \text{fare} &= \frac{A_e}{80{,}000} = \frac{\$70{,}254.32}{80{,}000} \\ &= \$0.878/\text{passenger} \end{aligned}$$

The passenger fare should go up each year by

$$\begin{aligned} \$0.878 &= \$0.35 + G\,(A/G, 7\%, 20) \\ G &= \frac{\$0.878 - \$0.35}{7.3163} \\ &= \$0.072 \text{ increase per year} \end{aligned}$$

The answer is (D).
26.

Use the present worth comparison method (also *NCEES Handbook:* Cost Estimation and Project Evaluation).

$$\begin{aligned} P\,(\text{A}) &= (\$4800)\,(P/A, 12\%, 25) \\ &= (\$4800)\,(7.8431) \\ &= \$37{,}646.88 \end{aligned}$$

(4 quarters)(25 years) = 100 compounding periods

$$\begin{aligned} P\,(\text{B}) &= (\$1200)\,(P/A, 3\%, 100) \\ &= (\$1200)\,(31.5989) \\ &= \$37{,}918.68 \end{aligned}$$

Alternative B is economically superior.

The answer is (B).

27.

Use the equivalent uniform annual cost method (also *NCEES Handbook:* Cost Estimation and Project Evaluation).

$$\begin{aligned} \text{EUAC}\,(\text{A}) &= (\$1500)\,(A/P, 15\%, 5) + \$800 \\ &= (\$1500)\,(0.2983) + \$800 \\ &= \$1247.45 \end{aligned}$$

$$\begin{aligned} \text{EUAC}\,(\text{B}) &= (\$2500)\,(A/P, 15\%, 8) + \$650 \\ &= (\$2500)\,(0.2229) + \$650 \\ &= \$1207.25 \end{aligned}$$

Alternative B is economically superior.

The answer is (B).

28.

The data given imply that both investments return 4% or more. However, the increased investment of \$30,000 may not be cost effective. Do an incremental analysis (see *NCEES Handbook:* Cost Estimation and Project Evaluation).

incremental cost = \$70,000 – \$40,000 = \$30,000

incremental income = \$5620 – \$4075 = \$1545

$$\begin{aligned} 0 &= -\$30{,}000 + (\$1545)\,(P/A, i\%, 20) \\ (P/A, i\%, 20) &= 19.417 \\ i &\approx 0.25\% < 4\% \end{aligned}$$

Alternative B is economically superior.

(The same conclusion could be reached by taking the present worths of both alternatives at 4%.)

The answer is (B).
29.

The present worth comparison is

$$\begin{aligned} P(\mathrm{A}) &= (-\$3000)(P/A, 25\%, 25) - \$20{,}000 \\ &= (-\$3000)(3.9849) - \$20{,}000 \\ &= -\$31{,}954.70 \\ P(\mathrm{B}) &= (-\$2500)(3.9849) - \$25{,}000 \\ &= -\$34{,}962.25 \end{aligned}$$

Alternative A is economically superior.

The answer is (A).

30.

As in *NCEES Handbook:* Cost Estimation and Project Evaluation, the depreciation in the first five years is

$$\begin{aligned} \mathrm{BV} &= \$18{,}000 - (5)\left(\frac{\$18{,}000 - \$2000}{8}\right) \\ &= \$8000 \end{aligned}$$

The answer is (D).

31.

Use the equivalent uniform annual cost method (also *NCEES Handbook:* Cost Estimation and Project Evaluation) to find the best alternative.

$$(A/P, 12\%, 15) = 0.1468$$

$$\begin{aligned} \mathrm{EUAC}_{5\ \mathrm{ft}} &= (\$600{,}000)(0.1468) \\ &\quad + \left(\frac{14}{50}\right)(\$600{,}000) + \left(\frac{8}{50}\right)(\$650{,}000) \\ &\quad + \left(\frac{3}{50}\right)(\$700{,}000) + \left(\frac{1}{50}\right)(\$800{,}000) \\ &= \$418{,}080 \end{aligned}$$

$$\begin{aligned} \mathrm{EUAC}_{10\ \mathrm{ft}} &= (\$710{,}000)(0.1468) \\ &\quad + \left(\frac{8}{50}\right)(\$650{,}000) + \left(\frac{3}{50}\right)(\$700{,}000) \\ &\quad + \left(\frac{1}{50}\right)(\$800{,}000) \\ &= \$266{,}228 \end{aligned}$$

$$\begin{aligned} \mathrm{EUAC}_{15\ \mathrm{ft}} &= (\$900{,}000)(0.1468) \\ &\quad + \left(\frac{3}{50}\right)(\$700{,}000) + \left(\frac{1}{50}\right)(\$800{,}000) \\ &= \$190{,}120 \\ \mathrm{EUAC}_{20\ \mathrm{ft}} &= (\$1{,}000{,}000)(0.1468) \\ &\quad + \left(\frac{1}{50}\right)(\$800{,}000) \\ &= \$162{,}800 \end{aligned}$$

Build to 20 ft.

The answer is (D).

32.

Calculate the EUAC for the options given in the multiple choice answers.

Assume replacement after three years.

$$\begin{aligned}\text{EUAC}\,(3) &= (\$30{,}000)\,(A/P, 12\%, 3) \\ &\quad + \$18{,}700 + (\$1200)\,(A/G, 12\%, 3) \\ &= (\$30{,}000)\,(0.4163) + \$18{,}700 \\ &\quad + (\$1200)\,(0.9246) \\ &= \$32{,}299\end{aligned}$$

Similarly, calculate to obtain the numbers in the following table.

years in service	EUAC
3	\$32,299
6	\$28,602
8	\$28,234
10	\$28,312

Replace after eight years.

The answer is (C).

33.

Since the head and horsepower data are already reflected in the hourly operating costs, there is no need to work with head and horsepower.

Use N = no. of hours operated each year.

$$\begin{aligned}\text{EUAC(A)} &= (\$3600 + \$3050)\,(A/P, 12\%, 10) \\ &\quad - (\$200)\,(A/F, 12\%, 10) + 0.30N \\ &= (\$6650)\,(0.1770) - (\$200)\,(0.0570) + 0.30N \\ &= 1165.65 + 0.30N \\ \text{EUAC(B)} &= (\$2800 + \$5010)\,(A/P, 12\%, 10) \\ &\quad + (\$280)\,(A/F, 12\%, 10) + 0.10N \\ &= (\$7810)\,(0.1770) - (\$280)\,(0.0570) + 0.10N \\ &= 1366.41 + 0.10N\end{aligned}$$

$$\begin{aligned}\text{EUAC(A)} &= \text{EUAC(B)} \\ 1165.65 + 0.30N &= 1366.41 + 0.10N \\ N &= 1003.8\ \text{hr} \quad (1000\ \text{hr})\end{aligned}$$

The answer is (A).

34.

First check that both alternatives have an ROR greater than the MARR. Work in thousands of dollars. Evaluate alternative A using *NCEES Handbook:* Cost Estimation and Project Evaluation.

$$\begin{aligned}P(\text{A}) &= -\$120 + (\$15)\,(P/F, i\%, 5) \\ &\quad + (\$57)\,(P/A, i\%, 5)\,(1 - 0.45) \\ &\quad + \left(\frac{\$120 - \$15}{5}\right)(P/A, i\%, 5)\,(0.45) \\ &= -\$120 + (\$15)\,(P/F, i\%, 5) \\ &\quad + (\$40.8)\,(P/A, i\%, 5)\end{aligned}$$

Try 15%.

$$\begin{aligned} P(\mathrm{A}) &= -\$120 + (\$15)(0.4972) + (\$40.8)(3.3522) \\ &= \$24.23 \end{aligned}$$

Try 25%.

$$\begin{aligned} P(\mathrm{A}) &= -\$120 + (\$15)(0.3277) + (\$40.8)(2.6893) \\ &= -\$5.36 \end{aligned}$$

Since P(A) goes through 0,

$$(\mathrm{ROR})_{\mathrm{A}} > \mathrm{MARR} = 15\%$$

Next, evaluate alternative B.

$$\begin{aligned} P(\mathrm{B}) &= -\$170 + (\$20)(P/F, i\%, 5) \\ &\quad + (\$67)(P/A, i\%, 5)(1 - 0.45) \\ &\quad + \left(\frac{\$170 - \$20}{5}\right)(P/A, i\%, 5)(0.45) \\ &= -\$170 + (\$20)(P/F, i\%, 5) \\ &\quad + (\$50.35)(P/A, i\%, 5) \end{aligned}$$

Try 15%.

$$\begin{aligned} P(\mathrm{B}) &= -\$170 + (\$20)(0.4972) + (\$50.35)(3.3522) \\ &= \$8.73 \end{aligned}$$

Since $P(\mathrm{B}) > 0$ and will decrease as i increases,

$$(\mathrm{ROR})_{\mathrm{B}} > 15\%$$

ROR > MARR for both alternatives.

The answer is (C).
35.

Use the year-end convention with the tax credit. The purchase is made at $t = 0$. However, the credit is received at $t = 1$ and must be multiplied by $(P/F, i\%, 1)$. As in *NCEES Handbook:* Cost Estimation and Project Evaluation,

$$\begin{aligned} P &= -\$300{,}000 + (0.0667)(\$300{,}000)(P/F, i\%, 1) \\ &\quad + (\$90{,}000)(P/A, i\%, 5)(1 - 0.48) \\ &\quad + \left(\frac{\$300{,}000 - \$50{,}000}{5}\right)(P/A, i\%, 5)(0.48) \\ &\quad + (\$50{,}000)(P/F, i\%, 5) \\ &= -\$300{,}000 + (\$20{,}010)(P/F, i\%, 1) \\ &\quad + (\$46{,}800)(P/A, i\%, 5) \\ &\quad + (\$24{,}000)(P/A, i\%, 5) \\ &\quad + (\$50{,}000)(P/F, i\%, 5) \end{aligned}$$

By trial and error,

i	P
10%	\$17,625
15%	−\$20,409
12%	\$1456
13%	−\$6134
$12\,^1/_4$%	−\$472

i is between 12% and $12^1/_4$%.

The answer is (C).
36.

The distributed profit is

$$\begin{aligned}\text{distributed profit} &= (0.15)(\$2{,}500{,}000) \\ &= \$375{,}000\end{aligned}$$

As in *NCEES Handbook:* Cost Estimation and Project Evaluation, find the annual loan payment.

$$\begin{aligned}\text{payment} &= (\$2{,}500{,}000)(A/P, 12\%, 25) \\ &= (\$2{,}500{,}000)(0.1275) \\ &= \$318{,}750\end{aligned}$$

After paying all expenses and distributing the 15% profit, the remainder should be 0.

$$\begin{aligned}0 &= \text{EUAC} \\ &= \$20{,}000 + \$50{,}000 + \$200{,}000 \\ &\quad + \$375{,}000 + \$318{,}750 - \text{annual receipts} \\ &\quad - (\$500{,}000)(A/F, 15\%, 25) \\ &= \$963{,}750 - \text{annual receipts} \\ &\quad - (\$500{,}000)(0.0047)\end{aligned}$$

This calculation assumes $i = 15\%$, which equals the desired return. However, this assumption only affects the salvage calculation, and since the number is so small, the analysis is not sensitive to the assumption.

$$\text{annual receipts} = \$961{,}400$$

The average daily receipts are

$$\frac{\$961{,}400}{365} = \$2634$$

Use the expected value approach. The average occupancy is

$$\begin{aligned}&(0.40)(0.65) + (0.30)(0.70) + (0.20)(0.75) \\ &\quad + (0.10)(0.80) = 0.70\end{aligned}$$

The average number of rooms occupied each night is

$$(0.70)(120 \text{ rooms}) = 84 \text{ rooms}$$

The minimum required average daily rate per room is

$$\frac{\$2634}{84} = \$31.36 \quad (\$31)$$

The answer is (D).

37.

The annual savings are

$$\begin{aligned}\text{annual savings} &= \left(\frac{0.69 - 0.47}{1000}\right)(\$3{,}500{,}000) = \$770 \\ P &= -\$7500 + (\$770 - \$200 - \$100) \\ &\quad \times (P/A, i\%, 25) = 0 \\ (P/A, i\%, 25) &= 15.957\end{aligned}$$

One can calculate *P*/*A* using the various i values from the answer selection to find that

$$
\begin{aligned}
(P/A, 3.8\%, 25) &= 15.957 \\
(P/A, 5.0\%, 25) &= 14.094 \\
(P/A, 13\%, 25) &= 7.330 \\
(P/A, 16\%, 25) &= 6.097
\end{aligned}
$$

The 3.8% interest rate gives the closest (exact) value to 15.957.

The answer is (A).

38.

Evaluate alternative A, working in millions of dollars and using *NCEES Handbook:* Cost Estimation and Project Evaluation.

$$
\begin{aligned}
P(\text{A}) &= -(\$1.3)(1-0.48)(P/A, 15\%, 6) \\
&= -(\$1.3)(0.52)(3.7845) \\
&= -\$2.56 \quad [\text{millions}]
\end{aligned}
$$

Use straight line depreciation to evaluate alternative B.

$$
\begin{aligned}
D_j &= \frac{\$2}{6} = \$0.333 \\
P(\text{B}) &= -\$2 - (0.20)(\$1.3)(1-0.48)(P/A, 15\%, 6) \\
&\quad - (\$0.15)(1-0.48)(P/A, 15\%, 6) \\
&\quad + (\$0.333)(0.48)(P/A, 15\%, 6) \\
&= -\$2 - (0.20)(\$1.3)(0.52)(3.7845) \\
&\quad - (\$0.15)(0.52)(3.7845) \\
&\quad + (\$0.333)(0.48)(3.7845) \\
&= -\$2.202 \quad [\text{millions}]
\end{aligned}
$$

Evaluate alternative C.

$$
\begin{aligned}
D_j &= \frac{1.2}{3} = 0.4 \\
P(\text{C}) &= -(\$1.2)\big(1 + (P/F, 15\%, 3)\big) \\
&\quad - (\$0.20)(\$1.3)(1-0.48) \\
&\quad \times \big((P/F, 15\%, 1) + (P/F, 15\%, 4)\big) \\
&\quad - (\$0.45)(\$1.3)(1-0.48) \\
&\quad \times \big((P/F, 15\%, 2) + (P/F, 15\%, 5)\big) \\
&\quad - (\$0.80)(\$1.3)(1-0.48) \\
&\quad \times \big((P/F, 15\%, 3) + (P/F, 15\%, 6)\big) \\
&\quad + (\$0.4)(\$0.48)(P/A, 15\%, 6) \\
&= -(\$1.2)(1.6575) \\
&\quad - (\$0.20)(\$1.3)(0.52)(0.8696 + 0.5718) \\
&\quad - (\$0.45)(\$1.3)(0.52)(0.7561 + 0.4972) \\
&\quad - (\$0.80)(\$1.3)(0.52)(0.6575 + 0.4323) \\
&\quad + (\$0.4)(0.48)(3.7845) \\
&= -\$2.428 \quad [\text{millions}]
\end{aligned}
$$

Alternative B is superior.

The answer is (B).

39.

This is a replacement study. Since production capacity and efficiency are not a problem with the defender, the only question is when to bring in the challenger. Since this is a before-tax problem, depreciation is not a factor, nor is book value. The cost of keeping the defender one more year is

$$\begin{aligned}\text{EUAC (defender)} &= \$200{,}000 + (0.15)\,(\$400{,}000)\\ &= \$260{,}000\end{aligned}$$

For the challenger, as in *NCEES Handbook:* Cost Estimation and Project Evaluation,

$$\begin{aligned}&\text{EUAC (challenger)}\\ &\quad = (\$800{,}000)\,(A/P, 15\%, 10) + \$40{,}000\\ &\qquad + (\$30{,}000)\,(A/G, 15\%, 10)\\ &\qquad - (\$100{,}000)\,(A/F, 15\%, 10)\\ &\quad = (\$800{,}000)\,(0.1993) + \$40{,}000\\ &\qquad + (\$30{,}000)\,(3.3832)\\ &\qquad - (\$100{,}000)\,(0.0493)\\ &\quad = \$296{,}006\end{aligned}$$

Since the defender is cheaper, keep it. The same analysis next year will give identical answers. Therefore, keep the defender for the next three years, at which time the decision to buy the challenger will be automatic.

Having determined that it is less expensive to keep the defender than to maintain the challenger for 10 years, determine whether the challenger is less expensive if retired before 10 years. If retired in nine years,

$$\begin{aligned}\text{EUAC (challenger)} &= (\$800{,}000)\,(A/P, 15\%, 9) + \$40{,}000\\ &\quad + (\$30{,}000)\,(A/G, 15\%, 9)\\ &\quad - (\$150{,}000)\,(A/F, 15\%, 9)\\ &= (\$800{,}000)\,(0.2096)\\ &\quad + \$40{,}000 + (\$30{,}000)\,(3.0922)\\ &\quad - (\$150{,}000)\,(0.0596)\\ &= \$291{,}506\end{aligned}$$

Similar calculations yield the following results for all the retirement dates.

n	EUAC
10	\$296,000
9	\$291,506
8	\$287,179
7	\$283,214
6	\$280,016
5	\$278,419
4	\$279,909
3	\$288,013
2	\$313,483
1	\$360,000

Since none of these equivalent uniform annual costs are less than that of the defender, it is not economical to buy and keep the challenger for any length of time.

Keep the defender.

The answer is (D).
40.

With just-in-time manufacturing, production is one-at-a-time, according to demand. When one is needed, one is made. In order to make the economic order quantity approach zero, the setup cost must approach zero.

The answer is (D).

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