Diagnostic Examination

TOPIC XV: ENGINEERING ECONOMICS
TIME LIMIT: 45 MINUTES

1. Approximately how many years will it take to double an investment at a 6% effective annual rate?
   (A) 10 yr
   (B) 12 yr
   (C) 15 yr
   (D) 17 yr

2. An individual contributes $200 per month to a 401(k) retirement account. The account earns interest at a nominal annual interest rate of 8%, with interest being credited monthly. What is the value of the account after 35 years?
   (A) $368,000
   (B) $414,000
   (C) $447,000
   (D) $459,000

3. A graduating high school student decides to take a year off and work to save money for college. The student plans to invest all money earned in a savings account earning 6% interest, compounded quarterly. The student hopes to have $5000 by the time school starts in 12 months. How much money will the student have to save each month?
   (A) $396/mo
   (B) $405/mo
   (C) $407/mo
   (D) $411/mo

4. A gold mine is projected to produce $20,000 during its first year of operation, $19,000 the second year, $18,000 the third year, and so on. If the mine is expected to produce for a total of 10 years, and the effective annual interest rate is 6%, what is its present worth?
   (A) $118,000
   (B) $125,000
   (C) $150,000
   (D) $177,000

5. $5000 is put into an empty savings account with a nominal interest rate of 5%. No other contributions are made to the account. With monthly compounding, how much interest will have been earned after five years?
   (A) $1250
   (B) $1380
   (C) $1410
   (D) $1420

6. An engineer deposits $10,000 in a savings account on the day her child is born. She deposits an additional $1000 on every birthday after that. The account has a 5% nominal interest rate, compounded continuously. How much money will be in the account the day after the child’s 21st birthday?
   (A) $36,200
   (B) $41,300
   (C) $64,800
   (D) $84,300

7. A machine costs $10,000 and can be depreciated over a period of four years, after which its salvage value will be $2000. What is the straight-line depreciation in year 3?
   (A) $2000
   (B) $2500
   (C) $4000
   (D) $6000

8. A groundwater treatment system is needed to remediate a solvent-contaminated aquifer. The system costs $2,500,000. It is expected to operate a total of 130,000 hours over a period of 10 years and then have a $250,000 salvage value. During its first year in service, it is operated for 6500 hours. What is its depreciation in the first year using the MACRS method?
   (A) $113,000
   (B) $125,000
   (C) $225,000
   (D) $250,000
9. A machine initially costing $25,000 will have a salvage value of $6,000 after five years. Using MACRS depreciation, what will its book value be after the third year?
   (A) $5,470
   (B) $7,200
   (C) $10,000
   (D) $13,600

10. Given the following cash flow diagram and an 8% effective annual interest rate, what is the equivalent annual expense over the five-year period?

   \[ t = 0 \]
   \[ \downarrow \]
   \[ \$50 \]
   \[ \downarrow \]
   \[ \$100 \]
   \[ \downarrow \]
   \[ \$150 \]
   \[ \downarrow \]
   \[ \$200 \]
   \[ \downarrow \]
   \[ \$500 \]

   (A) $209
   (B) $218
   (C) $251
   (D) $268

11. The construction of a volleyball court for the employees of a highly successful mid-sized publishing company in California is expected to cost $1200 and have annual maintenance costs of $300. At an effective annual interest rate of 5%, what is the project's capitalized cost?
   (A) $1500
   (B) $2700
   (C) $7200
   (D) $18,000

12. A warehouse building was purchased 10 years ago for $250,000. Since then, the effective annual interest rate has been 8%, inflation has been steady at 2.5%, and the building has had no deterioration or decrease in utility. What should the warehouse sell for today?
   (A) $427,000
   (B) $540,000
   (C) $678,000
   (D) $691,000

13. A delivery company is expanding its fleet by five vans at a total cost of $75,000. Operating and maintenance costs for the new vehicles are projected to be $20,000/year for the next eight years. After eight years, the vans will be sold for a total of $10,000. Annual revenues are expected to increase by $40,000 with the expanded fleet. What is the company's rate of return on the purchase?
   (A) 19.7%
   (B) 20.8%
   (C) 21.7%
   (D) 23.2%

14. A company is considering replacing its air conditioner. Management has narrowed the choices to two alternatives that offer comparable performance and considerable savings over their present system. The effective annual interest rate is 8%. What is the benefit-cost ratio of the better alternative?

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
</tr>
</thead>
<tbody>
<tr>
<td>initial cost</td>
<td>$7000</td>
<td>$9000</td>
</tr>
<tr>
<td>annual savings</td>
<td>$1500</td>
<td>$1900</td>
</tr>
<tr>
<td>salvage value life</td>
<td>$500</td>
<td>$-1250</td>
</tr>
</tbody>
</table>

   (A) 1.73
   (B) 1.76
   (C) 1.84
   (D) 1.88

15. A gourmet ice cream store has fixed expenses (rent, utilities, etc.) of $50,000/yr. Its two full-time employees each earn $25,000 per year. There is also a part-time employee who makes $14,000 plus $6000 in overtime if sales reach $120,000 in a year. The ice cream costs $4/L to produce and sells for $7/L. What is the minimum number of liters the store must sell to break even?
   (A) 38,000 L
   (B) 39,000 L
   (C) 40,000 L
   (D) 41,000 L
6. The uniform series compound amount factor does not include a contribution at \( t=0 \). Therefore, calculate the future value as the sum of a single payment and an annual series.

\[
F = P(F/P, r\%, n) + A(F/A, r\%, n) \\
= P(e^{rn}) + A\left(\frac{e^{rn} - 1}{r}\right) \\
= ($10,000)(e^{0.05(21)}) + ($1000)\left(\frac{e^{0.05(21)} - 1}{e^{0.05} - 1}\right) \\
= $64,808 \quad ($64,500)
\]

**Answer is C.**

7. With the straight-line method, depreciation is the same in each year.

**Answer is C.**

8. MACRS depreciation depends only on the original cost, not on the salvage value or hours of operation.

**Answer is C.**

9. Book value is the initial cost less the accumulated depreciation. Use the MACRS factors for a five-year recovery period.

\[
BV = C - \sum_{j=1}^{5} D_j \\
= C - \sum_{j=1}^{3} (C(\text{factor}_j)) \\
= C\left(1 - \sum_{j=1}^{3} \text{factor}_j\right) \\
= ($25,000)\left(1 - (0.20 + 0.32 + 0.192)\right) \\
= $7200
\]

**Answer is B.**

10. First, find the present value of all of the cash flows.

Next, find the

**Answer is**

11. Find the capitalized cost of the annual maintenance and add the initial construction cost to it.

\[
P = C + \frac{A}{i} = $1200 + \frac{$300}{0.05} \\
= $7200
\]

**Answer is C.**

12. Ideally, the current price should be the future worth (from 10 years ago) adjusted for inflation. Use the inflation-adjusted interest rate, \( d \), together with the single payment compound amount factor.

\[
d = i + f + if \\
= 0.08 + 0.025 + (0.08)(0.025) \\
= 0.107
\]

\[
P = P(F/P, d\%, n) \\
= ($250,000)(1 + 0.107)^{10} \\
= $690,902 \quad ($691,000)
\]

**Answer is D.**
**SOLUTIONS**

1. Determine the number of years for the compound amount factor to equal 2.

   Alternatively, use the 6% factor table. \( n \) is approximately 12 years.

   **Answer is B.**

2. The effective rate per month is

   \[
i = \frac{r}{m} = \frac{0.08}{12} = 0.00667
   \]

   Use the uniform series compound amount factor.

   \[F = A\left(\frac{F}{A}, i\%, n\right)\]

   Because compounding is monthly, \( n \) is the number of months.

   \[n = (35 \text{ yr})\left(\frac{12 \text{ mo}}{\text{yr}}\right) = 420 \text{ mo}\]

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

   \[= (\$200)\left(\frac{(1 + 0.00667)^{420} - 1}{0.00667}\right)\]

   \[= $459,227 \quad (\$459,000)\]

   **Answer is D.**

3. The effective rate per quarter is

   \[
i = \frac{r}{m} = \frac{0.06}{4} = 0.015
   \]

   There are four compounding periods during the year.

   \[n = 4\]

   Use the sinking fund factor.

   \[A = F\left(\frac{A}{F}, i\%, n\right)\]

   \[= (\$5000)\left(\frac{F}{A}, 1.5\%, 4\right)\]

   \[= (\$5000)\left(\frac{0.015}{(1 + 0.015)^4 - 1}\right)\]

   \[= $1222\]

   \[\text{monthly savings} = \frac{1222 \text{ \$}}{3 \frac{\text{quarter}}{\text{quarter}}} = \frac{\$407}{\text{mo}}\]

   **Answer is C.**

4. This cash flow is equivalent to a $20,000 annual series with a $1000/year gradient. Use the factor tables.

   \[P = (\$20,000)(P/A, 6\%, 10) - (\$1000)(P/G, 6\%, 10)\]

   \[= (\$20,000)(7.3601) - (\$1000)(29.6023)\]

   \[= $117,600 \quad (\$118,000)\]

   **Answer is A.**

5. The effective annual interest rate is

   \[i_e = \left(1 + \frac{r}{m}\right)^m - 1\]

   \[= \left(1 + \frac{0.05}{12}\right)^{12} - 1\]

   \[= 0.05116\]

   The total future value is

   \[F = P\left(\frac{F}{P}, i\%, n\right) = P(1 + i)^n\]

   \[= (\$5000)(1 + 0.05116)^8\]

   \[= $6417\]

   The interest available is

   \[\text{interest} = F - P = $6417 - $5000\]

   \[= $1417 \quad (\$1420)\]

   (This problem can also be solved by calculating the effective interest rate per period and compounding for 60 months.)

   **Answer is D.**
13. Rate of return is the effective annual interest rate that would make the investment's present worth zero.

Answer is C.

14. Compute the present worth of the benefits and costs for each alternative. Salvage value should be counted as a decrease in cost, not as a benefit.

For alternative I,

\[ B = (1500)(P/A, 8\%, 15) \]
\[ = (1500)(8.5595) \]
\[ = 12,839 \]
\[ C = 7000 - (500)(P/F, 8\%, 15) \]
\[ = 7000 - (500)(0.3152) \]
\[ = 6842 \]
\[ \frac{B}{C} = \frac{12,839}{6842} = 1.88 \]

For alternative II,

\[ B = (1900)(P/A, 8\%, 15) \]
\[ = (1900)(8.5595) \]
\[ = 16,263 \]
\[ C = 9000 + (1250)(P/F, 8\%, 15) \]
\[ = 9000 + (1250)(0.3152) \]
\[ = 9394 \]
\[ \frac{B}{C} = \frac{16,263}{9394} = 1.73 \]

The alternatives cannot be compared to one another based simply on their ratios. Instead, perform an incremental analysis.

\[ \frac{B_B - B_A}{C_B - C_A} = \frac{16,263 - 12,839}{9394 - 6842} = 1.34 \]

Because the incremental analysis ratio is greater than one, alternative II is superior.

Answer is A.

15. Calculate the costs and revenues assuming sales of $120,000 are exceeded.

\[ \text{costs} = 50,000 + (2)(25,000) + 14,000 \]
\[ + 6000 + \left(4 \frac{5}{L}\right)Q \]
\[ \text{revenues} = \left(7 \frac{5}{L}\right)Q \]

At the break-even point, costs equal revenues.

\[ \left(7 \frac{5}{L}\right)Q = 120,000 + \left(4 \frac{5}{L}\right)Q \]
\[ Q = 40,000 \text{ L} \]

Check the assumption that sales exceed $120,000.

\[ \left(7 \frac{5}{L}\right)(40,000 \text{ L}) = 280,000 \quad [\text{ok}] \]

Answer is C.
There are no tables for this interest rate.

\[
(P/A, 0.579\%, 360) = \frac{(1 + i)^n - 1}{i(1 + i)^n} = \frac{(1 + 0.00579)^{360} - 1}{0.00579(1 + 0.00579)^{360}} = 151.10
\]

\[
P = A(P/A, 0.579\%, 360) = (\$550)(151.10) = \$83,105
\]

Answer is B.

Problem 6

The designer of the penstock for a small hydroelectric cogeneration station has the option of using steel pipe, which costs $150,000 installed and requires $5000 yearly for painting and leak-checking maintenance, or DSR4.3 (heavy-duty plastic) pipe, which costs $180,000 installed and requires $1200 yearly for leak-checking maintenance. Both options have an expected life of 25 years. If the interest rate is 8%, which choice has the lower present equivalent cost and how much lower is it?

(A) DSR4.3 costs less by $10,600.

(B) Steel pipe costs less by $10,600.

(C) DSR4.3 costs less by $65,000.

(D) Steel pipe costs less by $65,000.

Solution

The problem requires a comparison of the uniform series present worth of each alternative.

For steel pipe,

\[
\begin{array}{c}
t = 0 \\
\downarrow \\
\$150,000 \\
\downarrow \\
\vdots \\
\downarrow \\
\vdots \\
\downarrow \\
\vdots \\
\downarrow \\
A = \$5000 \\
\end{array}
\]

\[
t = 25
\]

\[
P(\text{steel pipe}) = \$150,000 + A(P/A, 8\%, 25)
\]

\[
= \$150,000 + (\$5000)(10.6748)
\]

\[
= \$203,374
\]

\[
P(\text{DSR4.3}) = \$180,000 + A(P/A, 8\%, 25)
\]

\[
= \$180,000 + (\$1200)(10.6748)
\]

\[
= \$192,810
\]

Using DSR4.3 is less expensive by

\[
\$203,374 - \$192,810 = \$10,564 \quad (10,600)
\]

Answer is A.

FE-STYLE EXAM PROBLEMS

1. If the interest rate on an account is 11.5% compounded yearly, approximately how many years will it take to triple the amount?

   (A) 8 years
   
   (B) 9 years
   
   (C) 10 years
   
   (D) 11 years

2. Fifteen years ago $1000 was deposited in a bank account, and today it is worth $2370. The bank pays interest semi-annually. What was the nominal annual interest rate paid on this account?

   (A) 2.9%
   
   (B) 4.4%
   
   (C) 5.0%
   
   (D) 5.8%

3. Mr. Jones plans to deposit $500 at the end of each month for 10 years at 12% annual interest, compounded monthly. The amount that will be available in two years is

   (A) $13,000
   
   (B) $13,500
   
   (C) $14,000
   
   (D) $14,500
4. The purchase price of a car is $25,000. Mr. Smith makes a down payment of $5000 and borrows the balance from a bank at 6% annual interest, compounded monthly for five years. Calculate the nearest value of the required monthly payments to pay off the loan.

(A) $350
(B) $400
(C) $450
(D) $500

5. A piece of machinery can be bought for $10,000 cash or for $2000 down and payments of $750 per year for 15 years. What is the annual interest rate for the time payments?

(A) 1.51%
(B) 4.51%
(C) 7.71%
(D) 12.0%

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

6. You have borrowed $5000 and must pay it off in five equal annual payments. Your annual interest rate is 10%. How much interest will you pay in the first two years?

(A) $855
(B) $868
(C) $875
(D) $918

7. A company puts $25,000 down and will pay $5000 every year for the life of a machine (10 years). If the salvage value is zero and the interest rate is 10% compounded annually, what is the present value of the machine?

(A) $55,700
(B) $61,400
(C) $75,500
(D) $82,500

8. You borrow $3500 for one year from a friend at an interest rate of 1.5% per month instead of taking a loan from a bank at a rate of 18% per year. Compare how much money you will save or lose on the transaction.

(A) You will pay $55 more than if you borrowed from the bank.
(B) You will pay $630 more than if you borrowed from the bank.
(C) You will pay $685 more than if you borrowed from the bank.
(D) You will save $55 by borrowing from your friend.

9. If you invest $25,000 at 8% interest compounded annually, approximately how much money will be in the account at the end of 10 years?

(A) $31,000
(B) $46,000
(C) $54,000
(D) $75,000

10. A college student borrows $10,000 today at 10% interest compounded annually. Four years later, the student makes the first repayment of $3000. Approximately how much money will the student still owe on the loan after the first payment?

(A) $7700
(B) $8300
(C) $11,000
(D) $11,700

11. A 40-year-old consulting engineer wants to set up a retirement fund to be used starting at age 65. $20,000 is invested now at 6% compounded annually. Approximately how much money will be in the fund at retirement?

(A) $84,000
(B) $86,000
(C) $88,000
(D) $92,000
12. The maintenance cost for a car this year is expected to be $500. The cost will increase $50 each year for the subsequent 9 years. The interest is 8% compounded annually. What is the approximate present worth of maintenance for the car over the full 10 years?

(A) $4300  
(B) $4700  
(C) $5300  
(D) $5500

13. A house is expected to have a maintenance cost of $1000 the first year. It is believed that the maintenance cost will increase $500 per year. The interest rate is 6% compounded annually. Over a 10-year period, what will be the approximate effective annual maintenance cost?

(A) $1900  
(B) $3000  
(C) $3500  
(D) $3800

14. You deposited $10,000 in a savings account five years ago. The account has earned 5.25% interest compounded continuously since then. How much money is in the account today?

(A) $12,800  
(B) $12,900  
(C) $13,000  
(D) $13,600

15. A young engineer wants to surprise her husband with a European vacation for their tenth anniversary, which is five years away. She determines that the trip will cost $8000. Assuming an interest rate of 5.50% compounded daily, approximately how much money does she need to deposit today for the trip?

(A) $3790  
(B) $3800  
(C) $3880  
(D) $3930

16. A young woman plans to retire in 30 years. She intends to contribute the same amount of money each year to her retirement fund. The fund earns 10% compounded annually. She would like to withdraw $100,000 each year for 20 years, starting 1 year after the last contribution is made. Approximately how much money should she contribute to her retirement fund each year?

(A) $490  
(B) $570  
(C) $5200  
(D) $11,000

17. A deposit of $1000 is made in a bank account that pays 8% interest compounded annually. Approximately how much money will be in the account after 10 years?

(A) $1890  
(B) $2000  
(C) $2160  
(D) $2240

18. A deposit of $1000 is made in a bank account that pays 24% interest per year compounded quarterly. Approximately how much money will be in the account after 10 years?

(A) $7000  
(B) $7200  
(C) $8600  
(D) $10,000

19. A machine costs $20,000 today and has an estimated scrap cash value of $2000 after eight years. Inflation is 8% per year. The effective annual interest rate earned on money invested is 8%. How much money needs to be set aside each year to replace the machine with an identical model eight years from now?

(A) $2970  
(B) $3000  
(C) $3290  
(D) $3510

20. At what rate of annual interest will an investment quadruple itself in 12 years?

(A) 10.1%  
(B) 11.2%  
(C) 12.2%  
(D) 13.1%
Problem 3

Referring to the machine described in Prob. 1, what is the book value after five years using the MACRS method of depreciation?

(A) $12,500  
(B) $16,400  
(C) $18,500  
(D) $21,900

Solution

Using Eq. 52.4,

\[ BV = C - \sum_{j=1}^{5} D_j \]

To compute the depreciation in the first five years, use the MACRS factors for a 10-year recovery period.

<table>
<thead>
<tr>
<th>year</th>
<th>factor (%)</th>
<th>( D_j ) = (factor) ( C )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10.0</td>
<td>0.10 ( C ) = (factor) ( C )</td>
</tr>
<tr>
<td>2</td>
<td>18.0</td>
<td>0.18 ( C ) = (factor) ( C )</td>
</tr>
<tr>
<td>3</td>
<td>14.4</td>
<td>0.144 ( C ) = (factor) ( C )</td>
</tr>
<tr>
<td>4</td>
<td>11.5</td>
<td>0.115 ( C ) = (factor) ( C )</td>
</tr>
<tr>
<td>5</td>
<td>9.2</td>
<td>0.092 ( C ) = (factor) ( C )</td>
</tr>
</tbody>
</table>

\[ BV = C - \sum_{j=1}^{5} D_j = 50,000 - 31,550 = 18,450 \quad \text{(A) $18,500} \]

Answer is C.

Problem 4

A machine that costs $20,000 has a 10-year life and a $2000 salvage value. If straight-line depreciation is used, what is the book value of the machine at the end of the second year?

(A) $14,000  
(B) $14,400  
(C) $15,600  
(D) $16,400

Solution

Use straight-line depreciation.

\[ D_j = \frac{C - S_n}{n} \]

\[ = \frac{20,000 - 2000}{10} \]

\[ = $1800 \text{ per year} \]

\[ BV_2 = C - \sum_{j=1}^{2} D_j \]

\[ = 20,000 - 2 \times 1800 \]

\[ = $16,400 \]

Answer is D.

Problem 5

A $1000 face-value bond pays dividends of $110 at the end of each year. If the bond matures in 20 years, what is the approximate bond value at an interest rate of 12% per year, compounded annually?

(A) $890  
(B) $930  
(C) $1000  
(D) $1820

Solution

The bond value is the present value of the sum of annual interest payments and the present worth of the future face value of the bond.

\[ P = (110)(P/A, 12\%, 20) + (1000)(P/F, 12\%, 20) \]

\[ = (110) \left( \frac{(1.12)^{20} - 1}{(1.12)(1.12)^{20}} \right) + (1000)(1 + 0.12)^{-20} \]

\[ = (110)(7.4694) + (1000)(0.1037) \]

\[ = 925 \quad \text{(B) $930} \]

Answer is B.

FE-STYLE EXAM PROBLEMS

Problem 1 through Prob. 7 refer to the following situation.

A company is considering buying one of the following two computers.

<table>
<thead>
<tr>
<th>computer A</th>
<th>computer B</th>
</tr>
</thead>
<tbody>
<tr>
<td>initial cost</td>
<td>$3900</td>
</tr>
<tr>
<td>salvage value</td>
<td>$1800</td>
</tr>
<tr>
<td>useful life</td>
<td>10 years</td>
</tr>
<tr>
<td>annual maintenance</td>
<td>$390</td>
</tr>
<tr>
<td>interest rate</td>
<td>6%</td>
</tr>
</tbody>
</table>

What is the equivalent uniform annual cost of computer A?

(A) $740  
(B) $780  
(C) $820  
(D) $850
2. What is the equivalent uniform annual cost of computer B?
   (A) $770
   (B) $780
   (C) $850
   (D) $940

3. If computer A was to be purchased and kept forever without any change in the annual maintenance costs, what would be the present worth of all expenditures?
   (A) $3970
   (B) $7840
   (C) $10,000
   (D) $10,400

4. What is the annual straight-line depreciation for computer A?
   (A) $210/year
   (B) $225/year
   (C) $262/year
   (D) $420/year

5. What is the total straight-line depreciation value of computer A after the fifth year?
   (A) $1000
   (B) $1050
   (C) $1125
   (D) $1250

6. What is the book value of computer B after the second year, using the MACRS method of depreciation and a 10-year recovery period?
   (A) $3360
   (B) $3780
   (C) $3960
   (D) $4120

7. What is the present worth of the costs for computer A?
   (A) $5330
   (B) $5770
   (C) $6670
   (D) $6770

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

8. An investment proposal calls for a $100,000 payment now and a second $100,000 payment 10 years from now. The investment is for a project with a perpetual life. The effective annual interest rate is 6%. What is the approximate capitalized cost?
   (A) $156,000
   (B) $160,000
   (C) $200,000
   (D) $267,000

9. Depreciation allowance is best defined as
   (A) the value that a buyer will give a machine’s owner at the end of the machine’s useful life
   (B) the amount awarded to industries involved in removing natural limited resources from the earth
   (C) the amount used to recover the cost of an asset so that a replacement can be purchased
   (D) a factor whose use is regulated by federal law

10. Twenty thousand dollars is invested today. If the annual inflation rate is 6% and the effective annual return on investment is 10%, what will be the approximate future value of the investment, adjusted for inflation, in five years?
    (A) $26,800
    (B) $32,200
    (C) $42,000
    (D) $43,100

11. An investment currently costs $28,000. If the current inflation rate is 6% and the effective annual return on investment is 10%, approximately how long will it take for the investment’s future value to reach $40,000?
    (A) 1.8 years
    (B) 2.3 years
    (C) 2.6 years
    (D) 3.4 years
Problem 12 through Prob. 16 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. The connection will be needed for the foreseeable future. Both 80 mm and 120 mm pipes are being considered.

<table>
<thead>
<tr>
<th></th>
<th>80 mm pipe</th>
<th>120 mm pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>initial cost</td>
<td>$1500</td>
<td>$2500</td>
</tr>
<tr>
<td>service life</td>
<td>12 years</td>
<td>12 years</td>
</tr>
<tr>
<td>salvage value</td>
<td>$200</td>
<td>$300</td>
</tr>
<tr>
<td>annual maintenance</td>
<td>$400</td>
<td>$300</td>
</tr>
<tr>
<td>pump cost/hour</td>
<td>$2.50</td>
<td>$1.40</td>
</tr>
<tr>
<td>pump operation</td>
<td>600 hours/yr</td>
<td>600 hours/yr</td>
</tr>
</tbody>
</table>

For this analysis, the company will use an annual interest rate of 8%. 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.

12. Disregarding the initial and replacement pipe costs, what is the approximate capitalized cost of the maintenance and pumping costs for the 80 mm pipe?

   (A) $15,100
   (B) $20,100
   (C) $23,800
   (D) $27,300

13. What is the approximate equivalent uniform annual cost of the 80 mm pipe, considering all costs and expenses?

   (A) $1710
   (B) $1800
   (C) $1900
   (D) $2100

14. What is the approximate equivalent uniform annual cost of the 120 mm pipe, considering all costs and expenses?

   (A) $1250
   (B) $1290
   (C) $1380
   (D) $1460

15. What is the approximate depreciation allowance for the 120 mm pipe in the first year? Use MACRS depreciation assuming a 10-year life.

   (A) $193
   (B) $210
   (C) $230
   (D) $250

16. If the annual effective rates for inflation and interest have been 5% and 9%, respectively, what was the uninfated present worth of the 120 mm pipe three years ago?

   (A) $1590
   (B) $1670
   (C) $1710
   (D) $1780

17. Permanent mineral rights on a parcel of land are purchased for an initial lump-sum payment of $100,000. Profits from mining activities are $12,000 each year, and these profits are expected to continue indefinitely. What approximate interest rate is being earned on the initial investment?

   (A) 8.33%
   (B) 9.00%
   (C) 10.0%
   (D) 12.0%

18. Flood damage in a typical year is given according to the following table.

<table>
<thead>
<tr>
<th>value of flood damage</th>
<th>probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0</td>
<td>0.75</td>
</tr>
<tr>
<td>$10,000</td>
<td>0.20</td>
</tr>
<tr>
<td>$20,000</td>
<td>0.04</td>
</tr>
<tr>
<td>$30,000</td>
<td>0.01</td>
</tr>
</tbody>
</table>

   If the effective annual interest rate is 6%, what is the most likely present worth of flood damage over the next 10-year period?

   (A) $3100
   (B) $9600
   (C) $16,000
   (D) $23,000
(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 values.  
For snowplow A,

\[
C = 300,000 + (45,000) (P/A, 10\%, 10)  
= 300,000 + (45,000)(6.1446)  
= 576,507  
B = (150,000)(P/A, 10\%, 10)  
= (150,000)(6.1446)  
= 921,690  
\frac{B}{C} = \frac{921,690}{576,507}  
= 1.6
\]

For snowplow B,

\[
C = 400,000 + (35,000)(P/A, 10\%, 10)  
- (10,000)(P/F, 10\%, 10)  
= 400,000 + (35,000)(6.1446) - (10,000)(0.3855)  
= 611,206  
B = (200,000)(P/A, 10\%, 10)  
= (200,000)(6.1446)  
= 1,228,920  
\frac{B}{C} = \frac{1,228,920}{611,206}  
= 2.0
\]

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

\[
\frac{B_2 - B_1}{C_2 - C_1} \geq 1 \quad \text{[for choosing alternative 2]}  
\frac{B_2 - B_1}{C_2 - C_1} = \frac{1,228,920 - 921,690}{611,206 - 576,507}  
= 8.85 > 1
\]

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 lawn mower 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.

\[
\begin{align*}  
\text{costs} &= 750,000 + (1.35)(\text{no. of gears})  
\text{revenues} &= (7.35)(\text{no. of gears})  
750,000 + (1.35)(\text{no. of gears}) &= (7.35)(\text{no. of gears})  
\text{no. of gears} &= \frac{750,000}{7.35 - 1.35}  
&= 125,000
\end{align*}
\]

**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?

<table>
<thead>
<tr>
<th></th>
<th>mill M</th>
<th>mill N</th>
</tr>
</thead>
<tbody>
<tr>
<td>initial cost</td>
<td>$7800</td>
<td>$14,400</td>
</tr>
<tr>
<td>salvage value</td>
<td>$0</td>
<td>$2700</td>
</tr>
<tr>
<td>annual operating cost</td>
<td>$1745</td>
<td>$1200</td>
</tr>
<tr>
<td>annual repair cost</td>
<td>$960</td>
<td>$540</td>
</tr>
</tbody>
</table>
(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.

<table>
<thead>
<tr>
<th></th>
<th>machine A</th>
<th>machine B</th>
</tr>
</thead>
<tbody>
<tr>
<td>initial cost</td>
<td>$20,000</td>
<td>$30,000</td>
</tr>
<tr>
<td>life</td>
<td>10 years</td>
<td>10 years</td>
</tr>
<tr>
<td>salvage value</td>
<td>$2000</td>
<td>$5000</td>
</tr>
<tr>
<td>annual receipts</td>
<td>$9000</td>
<td>$12,000</td>
</tr>
<tr>
<td>annual disbursements</td>
<td>$3500</td>
<td>$4500</td>
</tr>
</tbody>
</table>

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

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

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.
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.

<table>
<thead>
<tr>
<th>course of action</th>
<th>seat</th>
<th>stem</th>
<th>body</th>
</tr>
</thead>
<tbody>
<tr>
<td>repair valve</td>
<td>50%</td>
<td>41%</td>
<td>21%</td>
</tr>
<tr>
<td>replace valve</td>
<td>35%</td>
<td>27%</td>
<td>9%</td>
</tr>
<tr>
<td>no action</td>
<td>65%</td>
<td>53%</td>
<td>42%</td>
</tr>
</tbody>
</table>

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 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.

<table>
<thead>
<tr>
<th></th>
<th>120 mm pipe</th>
<th>180 mm pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial cost</td>
<td>$2500</td>
<td>$3500</td>
</tr>
<tr>
<td>Service life</td>
<td>12 years</td>
<td>12 years</td>
</tr>
<tr>
<td>Salvage value</td>
<td>$300</td>
<td>$400</td>
</tr>
<tr>
<td>Annual maintenance</td>
<td>$300</td>
<td>$200</td>
</tr>
<tr>
<td>Pump cost/hour</td>
<td>$1.40</td>
<td>$1.00</td>
</tr>
<tr>
<td>Pump operation</td>
<td>600 hours/yr</td>
<td>600 hours/yr</td>
</tr>
</tbody>
</table>

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

2 PROBLEMS