A STUDY TO DETERMINE THE VALUE OF MATHEMATICAL KNOWLEDGE TO HOME MANAGERS

By

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Hanna Stuart Chestnut
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I. INTRODUCTION

A. Preliminary Statement

The need of mathematical knowledge and the necessity for more quantitative and qualitative thinking on the part of the average home manager today is decidedly more real than apparent to him. He seems to feel that the knowledge of mathematics is valuable to only a few; consequently he does not consider its real and possible uses to himself. A mere glance into the various economic activities of many adults—their methods of buying, investing, and borrowing—reveals a great lack in understanding of the basic mathematical principles.

In the last few years the trend in buying has been toward the installment plan. The merchants advertised the plan widely, claiming that increased sales would make it possible for dealers to purchase and handle stocks in larger quantities, permitting them to sell on the installment plan at comparatively lower prices than had been possible under the old cash-payment method. The real-estate salesmen advocated the installment plan of buying as a means for increasing home ownership. The installment plan was said to encourage thrift and raise the standards of living. No doubt there is considerable merit to these arguments, especially if the psychological aspects of the situation are considered, but this study will deal only with the economic phase.
The average adult does not realize how much he pays for services in purchasing by the installment plan, nor is he able to make the computations necessary to determine the actual rates of interest he pays for these privileges. Statistics show that 95% of all automobiles, electric washers, refrigerators, household furniture, and so on, are being purchased on the installment-plan basis. In many cases, the actual annual rates involved are in excess of 100% interest.

It is a common occurrence for a person to become involved in debt without realizing that poor purchasing ability and inefficient spending have caused his trouble. Yet, this same person may say that he has no need for the elementary mathematics as taught in the arithmetic, algebra, finance, and statistics courses. However, it is largely the quantitative judgment that one develops from these courses that enables one to consider and to appreciate money values.

B. Statement of Problem

This study was made (1) to determine the value of a mathematical knowledge to home owners; (2) to determine the phases of mathematics used in ordinary financial problems of home management; and (3) to find what need there is for promoting a course of "Mathematics of Finance" and the subjects prerequisite to it in the high-school curriculum.

The problem is resolved into one of finding answers to such questions as the following:
1. What rate of interest is paid when the light bill is paid after the date due?

2. How much extra does it actually cost to buy a new automobile on the installment plan rather than to use the old one for a few more months until cash can be paid for the new one?

3. What rate of interest is paid for new furniture, the purchase of which could be deferred for a few months until enough has been saved to pay cash?

4. Where can the best investment be made?

5. Can these questions, vital to thrift, be easily determined by one having a working knowledge of mathematics as applied to finance?

6. What are the applications of mathematics in financial transactions of ordinary home management?

7. Is there a need for providing a semester course in "Mathematics of Finance" to be given in the twelfth grade?

8. Does such a course better fit the needs of all adults than the traditional courses in trigonometry and college algebra?

9. What is the relation of such a course to the course in algebra in the high-school curriculum?
C. Organization of Study

1. Collection of Data. The data for the problems were collected from: (1) public utility companies, (2) retailers of household furniture, (3) dealers in plumbing and heating equipment, (4) retailers of electric appliances, (5) short loan companies, (6) building and loan associations, and (7) automobile agencies.

Several business firms of Terre Haute were visited by the author. The cash and installment prices of things people need, together with those things most people buy from these firms, were obtained. From these firms were determined: (1) time usually allowed for payment, (2) amount of cash down payment required, (3) the size of payments required, (4) the financing charges, and (5) any other costs which might enter into the transaction. Where a carrying charge of a certain per cent of the unpaid balance was made, this charge was added to the cash price of the article to obtain the total cost. The cash price of the article was used as the present value in the problems. In some stores, the installment price was quoted, and a rate of discount was given for cash payment; the present value was obtained by deducting the amount of the cash discount from the quoted price. Some firms quoted the cash price; then they gave the number of payments and the size of the payments required to pay for the article on the installment plan.

2. Solution of Problems. The data were put in the form
of problems, and these problems were solved to find the
effective rates of interest. The problems included things
needed in and about the home, as well as the home itself.
Where different methods of handling the financing were quoted,
a problem was included for each method. For example, one
firm required twenty per cent of the cash price as down pay-
ment and a certain per cent on the unpaid balance as a carry-
ing charge (on electric refrigerators); another firm required
ten per cent on the unpaid balance as a carrying charge.
The length of time over which the payments extended made a
difference in carrying charges. Some problems were included
to show this difference.

3. Analysis of Mathematical Processes. The formulas
used for computation of the problems were analyzed to deter-
mine the phases and amount of algebra which were necessary
in order to understand them. The phases and amounts of alge-
brawhich would be necessary to develop ability to solve the
financial problems of home managers were determined from
these analyses.

4. Analysis of Texts. Thirteen second-course algebra
texts were analyzed to determine the number of pages devoted
to the topics listed in the above analysis of mathematical
processes. The purpose of this analysis was to determine
how much of the subject matter covered by the present high-
interest paid. The purpose was to determine how a high-
school algebra course is necessary as a prerequisite to a
phases and amounts of computational necessary to a
course in "Mathematics of Finance", as needed by home managers.
II. TYPE PROBLEMS IN HOME-MANAGEMENT FINANCE AND AN ANALYSIS OF THE ALGEBRAIC PROCESSES INVOLVED IN THEIR SOLUTION

It is quite obvious that if one were to list each type of financial transaction involving interest payments, made by the majority of home owners, the list would be decidedly long and varied. To tabulate and to use such an extended list would be tedious and time-consuming. It would seem, for the purpose of drawing sound conclusions relative to the need of home managers for financial training, quite sufficient to confine the investigation to the more common groups of transactions which constitute the bulk of the expense in financing the home. In this study the investigations were confined to transactions with the following types of firms:

1. The Public Utility Companies
2. Retailers of Household Furniture
3. Dealers in Plumbing and Heating Equipment
4. Retailers of Electric Appliances
5. Short Loan Companies
6. Building and Loan Companies
7. Automobile Agencies

The data were collected in the form of actual problems, which were solved to find the effective (annual) rates of interest paid. The solutions were analyzed to determine the phases and amounts of mathematics necessary to understand and solve such problems. The problems were solved by using the formulas and tables in William L. Hart's Mathematics of
Investments. The rates of interest are accurate to the third decimal place, five-place tables of logarithms having been used.

A. Problems of Public Utilities in Home Management

1. Gas Bill. For each bill not paid on time a ten per cent fee is added to the bill. If the bill is not paid at the specified time, a notice is sent to the customer, and a week thereafter service may be discontinued and the meter removed. Hence, all delinquent gas bills involve payment of interest for one week, according to the company contract.

a. Problem No. 1: If a gas bill amounts to $1.98, determine the rate of interest paid for one week's delinquency.

b. Solution:

$1.98 \times 0.10 = $0.20, amount added to bill.

$1.98 + $0.20 = $2.18, amount of bill when overdue.

\[
I = Prt. \quad 1
\]

\[
$0.20 = $1.98 \times \frac{7}{360} \times r/100
\]

\[
7.20 = .01386r
\]

\[
r = 519.480\%, \text{ the effective rate of interest.}
\]

c. Analysis: This contract interest is for one week.
c. Analysis: This problem involves the fundamental operations of algebra, the formula, and the solution of simple and fractional equations.

2. Water Bill. The water bill is payable every quarter year, with a minimum charge of $1.00 per month. The minimum bill will therefore be $3.00. An additional charge of 10% is made if the bill is not paid before or upon the tenth of the month. On the eleventh day of the month a notice is sent to the customer, and he then has until the nineteenth to make payment. If the bill is not paid then, a man calls at the house, gives final notice, and discontinues service unless arrangements are made for immediate payment. This gives the customer a maximum of nine days of delinquency, which nine days constitute the interest period.

a. Problem No. 2: Consider a minimum bill for computation. What will be the rate of interest on an overdue bill?

b. Solution:

\[ \$3.00 \times .10 = \$0.30, \text{ amount added to bill.} \]

\[ I = Prt. \]

\[ \$0.30 = \$3.00 \times \frac{9}{360} \times \frac{r}{100} \]

\[ 1200 = 3r \]

\[ r = 400\%, \text{ the effective rate of interest.} \]

c. Analysis: This problem involves the fundamental operations of algebra, the formula, and the solution of simple and fractional equations.
3. **Electric Power**. The charges for delinquency varied on different electric-service bills. On some it was found a 10% fee had been added; on others a larger fee was charged. On the minimum bill of seventy-five cents, a fee of ten cents was added. When the bill becomes overdue, a notice is sent; then, after five days, another notice is sent. Three days later, if the bill is not paid, a man calls at the house, gives final notice, and discontinues service unless arrangements are made for immediate payment. The term of delinquency is eight days, which eight days constitute the interest period.

a. Problem No. 3: An electric bill amounts to $1.12 net bill and $1.30 gross bill (the latter amount to be paid if the bill is overdue). Determine the rate of interest to be paid by the customer if he lets the bill become overdue and takes advantage of the maximum allowable period of delinquency.

b. Solution:

\[ I = Prt \]

\[ I = 0.18 \]

\[ 0.18 = 1.12 \times \frac{8}{360} \times r/100 \]

\[ 810 = 1.12r \]

\[ r = 723.210\% \], effective rate of interest.
c. Problem No. 4: If the electric bill is $3.38 net and $3.72 gross, find the rate of interest to be paid by the customer if he lets the electric bill become overdue.

d. Solution:
$3.72 - $3.38 = $0.34, amount paid for interest.

\[ I = Prt \]
\[ $0.34 = $3.38 \times \frac{8}{360} \times \frac{r}{100} \]
\[ 15.30 = .0338r \]
\[ r = 452.69\% \], effective rate of interest

e. Problem No. 5: The minimum electric bill is $0.75 net and the gross bill is $0.85. Find the rate paid for delinquency.

f. Solution:
$0.85 - $0.75 = $0.10, amount paid for delinquency.

\[ I = Prt \]
\[ $0.10 = $0.75 \times \frac{8}{360} \times \frac{r}{100} \]
\[ 450 = .75r \]
\[ r = 600\% \], effective rate of interest.

g. Analysis: These problems involved the fundamental operations of algebra, the formula, and the solution of simple and fractional equations.
B. Problems in Home-Equipment Buying

1. Furniture. The furniture dealers quote the price of the article for installment buying. If cash is paid, they usually allow a 10% discount. The cash down payment varies, but monthly payments usually required are such that the bill is expected to be paid within a year, eighteen months, or within twenty-four months at the most.

a. Problem No. 6: A bill of furniture amounted to $500.00. If cash was paid a 10% discount was given. The customer decided to pay $25.00 down, and the balance in eighteen equal monthly payments. What are the nominal, \( m = 12 \), and effective rates?\(^2\)

b. Solution:

\[
\begin{align*}
\text{\$500.00} & = \text{amount of bill.} \\
10\% & = \text{rate of discount if cash is paid.} \\
\text{\$500.00} \times .10 & = \text{\$50.00, amount of discount.} \\
\text{\$500.00} - \text{\$50.00} & = \text{\$450.00, cash value of furniture.} \\
\text{\$25.00} & = \text{down payment made by customer.} \\
\text{\$500.00} - \text{\$25.00} & = \text{\$475.00, amount yet to be paid.} \\
\text{\$450.00} - \text{\$25.00} & = \text{\$425.00, present value of amt. unpaid.} \\
18 \text{ mo.} & = \text{time for payment of account.} \\
\text{\$475.00}/18 & = \text{\$26.39, monthly payment.}
\end{align*}
\]

\[ A = R \left( \frac{1}{1 + j/m} \right) \]  

Formula 3

\[ \$425.00 = \$26.39 \left( \frac{1}{1 + 0.0051762} \right) \]

\[ a^{1/12} \text{ at } j/12 = 16.10458507 \]

Solving for \( j/12 \) by interpolation:

When \( j/12 = 1 \frac{1}{8}\% \), \( a^{1/12} = 16.21241395 \) \( \text{(1)} \)

When \( j/12 = ? \), \( a^{1/12} = 16.10458507 \) \( \text{(2)} \)

When \( j/12 = 1\frac{1}{2}\% \), \( a^{1/12} = 16.02954893 \) \( \text{(3)} \)

Diff. of (1) and (2) = .10782888

Diff. of (1) and (3) = .18286502

\[ j/12 = 1 \frac{1}{8}\% + \left( \frac{0.10782888}{0.18286502} \right) 1/8\% \]

\[ = .01125 + .00074 \]

\[ = .01199 \]

\[ j = 14.388\% \text{, nominal rate, } m = 12. \]

Solving for the effective rate:

\[ (1 + i) = (1 + j/m)^m \]  

Formula 5

\[ (1 + i) = (1 + j/12)^{12} \]

\[ \log(1 + i) = 12 \log(1 + j/12) \]

\[ = 12 \log(1.01199) \]

\[ = 12(0.0051762) \]

\[ = .0621144 \]

\[ (1 + i) = 1.15376 \]

\[ \text{The effective rate } = 15.376\% \text{, effective rate.} \]

---

3 William D. Hart, op. cit., p. 54

4 The effective rate is the one rate at which income
   Ibid., p. 62 and Table VIII

5 Ibid., p. 23
c. Development of \((1+i) = (1+i/m)^m\):

Let the interest rate per conversion period be \(r\), expressed as a decimal. Let \(P\) be the original principal and let \(A\) be the compound amount to which \(P\) accumulates by the end of \(k\) conversion periods.

Then,

\[ A = P(1+r)^k \quad \text{Formula 1} \]

Proof:

Original principal is \(P\)

Int. due at end of 1st period \(Pr\)

New principal is \(P + Pr\) \(= P(1+r)\)

Int. due at end of 2nd period \(P(1+r)r\)

New principal is \(P(1+r)^2\)

because \(P(1+r) + P(1+r)r = P(1+r)(1+r) = P(1+r)^2\)

By the end of each period the principal on hand at the beginning of the period has been multiplied by \((1+r)\). Hence, by the end of \(k\) periods, the original principal \(P\) has been multiplied \(k\) successive times by \((1+r)\), or by \((1+r)^k\). Therefore the compound amount after \(k\) periods, is \(P(1+r)^k\).

\((1+r)^k\) may be expanded by the binomial theorem, and, for extreme accuracy, use should be made of the binomial theorem.

Nominal rate is the rate per cent at which interest is earned during each conversion period.

The effective rate is the per cent at which interest is earned during each year.
Let $i$ represent the nominal rate,
let $i$ represent the corresponding effective rate,
and let $m$ represent the times per year the interest is converted.

$$i = \text{interest earned per year} \div \text{principal}$$

To determine a relation between $i$, $m$, and $i$.

In formula $A = P(1+r)^k$,
let $P = \$1$, $r = j/m$, $k = m$.

$$A = (1 + \frac{j}{m})^m,$$

$$I = A - P = (1 + \frac{j}{m})^m - 1$$

but

$$i = I/P \text{ by definition and when } P = 1.$$  

$$i = I$$

Hence,

$$i = (1 + \frac{j}{m})^m$$

$$1 + i = (1 + \frac{j}{m})^m$$  \text{ Formula 2}

d. Development of $(a_n^m) \text{ at } i$ formula:

When rate of interest is $i$, and present value is $a_n^m$, $(a_n^m \text{ at } i)$ or $a_n^m$ $i$ represents the present value of an annuity of $\$1$ per interest period for $n$ periods.

In Fig. 1, each division represents a conversion period, and the arrows indicate the periods for which each payment is discounted to obtain its present value.
These problems involve the fundamental operations in algebra, the formula, evaluating formulas, fractions, exponents (positive and negative), factoring, binomial theorem, progressions, and logarithms.

Subtracting equation (1) from equation (2):

\[ (1+i)(a_n i) - a_n i = 1 - (1+i)^{-n} \]

\[ (a_n i)(1+i -1) = 1 - (1+i)^{-n} \]

\[ a_n i = \frac{1 - (1+i)^{-n}}{i} \]

e. Analysis:

These problems involve the fundamental operations in algebra, the formula, evaluating formulas, fractions, exponents (positive and negative), factoring, binomial theorem, progressions, and logarithms.
f. Problem No. 7: The unpaid balance on a used piano was $100.00. The customer was given twelve months in which to pay the balance in payments of $9.49 per month. Find the nominal rate when m = 12 and the effective rate of interest.

g. Solution:

\[ A = R(a_m \text{ at } j/m) \]

$100.00 = present value

$9.49 = monthly payment

$100.00 = $9.49(a_{12} \text{ at } j/12)

(a_{12} \text{ at } j/12) = 10.53730242

Solving for \( j/12 \) by interpolation:

When \( j/12 = 2\% \), \( a_{12} = 10.57534122 \)  
(1)

When \( j/12 = ? \), \( a_{12} = 10.53730242 \)  
(2)

When \( j/12 = 2\frac{1}{2}\% \), \( a_{12} = 10.41477882 \)  
(3)

Diff. of (1) and (2) = .03803880

Diff. of (1) and (3) = .16056240

\[ j/12 = 2\% + \left( \frac{.03803880}{.16056240} \right) \]

\[ = .02 + .00059 \]

\[ = .02059 \]

\[ j = .24708 \]

= 24.708%, nominal rate, \( m = 12 \).

This was quoted as the monthly payment on a $100.00 debt for one year.
Solving for the effective rate:

\[(1 + i) = (1 + \frac{j}{12})^{12}\]

\[= 1.02059\]

\[\log(1 + i) = 12 \log(1.02059)\]

\[= .10632\]

\[(1 + i) = 1.27740\]

\[i = .27740\]

\[= 27.740\%,\text{ effective rate.}\]

2. **Heating Systems.** Where heating systems are purchased on the deferred payment plan, most contracts limit the payments to one year, payable in either weekly or monthly installments. One company, which did its own financing, had a twelve-month, an eighteen-month, and a twenty-four-month plan of payment. The cash down payments varied. Some merchants required a ten per cent cash payment; others required no set amount. The prices quoted were cash prices, and the fee added for installment buying was charged on the unpaid balance.

a. **Problem No. 8:** A furnace costing $280.00 (cash price) is bought and a $30.00 cash payment is made. The unpaid balance is to be paid in twelve equal monthly payments of $22.00.\(^7\) Find the nominal rate, \(m = 12\), and effective rate of interest.

\(^7\)Quoted monthly payment.
b. Solution:

\( \$80.00 - \$30.00 = \$250.00 \), unpaid balance.

\[ A = R \left( a_{12} \right) \text{ at } j/m. \]

\[ \$250.00 = \$22.00 \left( a_{\frac{1}{12}} \right) \text{ at } j/12 \]

\[ a_{\frac{1}{12}} \text{ at } j/12 = 11.36363636 \]

Solving for \( j/12 \) by interpolation:

When \( j/12 = \frac{1}{5} \), \( a_{\frac{1}{12}} = 11.6189321 \) \hspace{1cm} (1)

When \( j/12 = \frac{1}{6} \), \( a_{\frac{1}{12}} = 11.3636364 \) \hspace{1cm} (2)

When \( j/12 = \frac{1}{10} \), \( a_{\frac{1}{12}} = 11.2550775 \) \hspace{1cm} (3)

Diff. of (1) and (2) = 0.25529574

Diff. of (1) and (3) = 0.36385460

\[ j/12 = \frac{1}{6} + \left( \frac{0.25529574}{0.36385460} \right) \frac{1}{12} \]

\[ = 0.005 + 0.00351 \]

\[ = 0.00851 \]

Hence \( j = 0.10212 \), or \( 10.212\% \), nominal rate, \( m = 12 \).

Solving for the effective rate:

\[ (1 + i) = (1 + j/12)^{12} \]

\[ = (1.00851)^{12} \]

\[ \log(1 + i) = 12 \log(1.00851) \]

\[ = 0.04398 \]

\[ \text{Add of (1)} \]

\[ (1 + i) = 1.10575 \]

\[ = 1.10575 \]

\[ = 10.575\% \), effective rate. \]
c. Problem No. 9: The cash price quotation for a heating system was $300.00. The customer made a cash payment of $50.00 and contracted to pay the balance in eleven equal monthly payments. A carrying charge of 10% of the unpaid balance was made. Find the nominal, m = 12, and effective rates of interest.

d. Solution:

$300.00 - $50.00 = $250.00, unpaid balance.
$250.00 × .10 = $25.00, carrying charge.
$250.00 + $25.00 = $275.00, amount to be paid in installments.

275/11 = 425.00, amount of each monthly payment.

\[ A = R(a_{\frac{m}{12}} \text{ at } j/m) \]
\[ $250.00 = 25(a_{\frac{11}{12}} \text{ at } j/12) \]
\[ a_{\frac{11}{12}} \text{ at } j/12 = 10 \]

Solving for j/12 by interpolation:

When j/12 = 1\%2, a_{\frac{11}{12}} = 10.07111779 \hspace{1cm} (1)
When j/12 = 0, a_{\frac{11}{12}} = 10. \hspace{1cm} (2)
When j/12 = 1\%4, a_{\frac{11}{12}} = 9.92849181 \hspace{1cm} (3)

Diff. of (1) and (2) = .07111779
Diff. of (1) and (3) = .14362598

When the case arises:

\[ j/12 = 1\%2 + \left(\frac{7111779/14362598}{10.07111779 - 10.92849181}\right) \]
\[ = .015 + .00124 \]
\[ = .01624 \]
n. Problem No. 10

The payment plan formula:

\[ j = 19.488\%, \text{ nominal rate, } m = 12 \]
Solving for the effective rate:

\[(1 + i) = (1 + \frac{j}{m})^m\]

\[= (1 + \frac{j}{12})^{12}\]

\[= (1.01624)^{12}\]

\[\log(1 + i) = 12 \log(1.01624)\]

\[= 12(0.00697)\]

\[= 0.08388\]

\[(1 + i) = 1.21305\]

\[i = 21.305\%, \text{ effective rate.}\]

3. **Bathroom Fixtures and Plumbing.** Bathroom fixtures and plumbing may be purchased upon the same basis as in problem number nine. The nominal and effective rates would be the same as in that problem.

4. **Electric Appliances.** The smaller electrical appliances are sold by the electric utilities companies, for a down payment of one dollar ($1.00) with the balance payable in six monthly payments and a carrying charge of ten per cent. Cash payments on refrigerators varied from ten per cent to twenty per cent of the value of the bill, while the cash payment on radios at the different stores varied from any payment the customer cared to make up to twenty per cent of the bill. Electric appliances sell at the furniture stores under the same plan as furniture.

a. **Problem No. 10:** An electric iron was bought on the payment plan from the electric utility company for $7.85. The company required a down payment of $1.00, the balance to be paid in six equal monthly
payments with a carrying charge of 10% added. What are the nominal, \( m = 12 \), and effective rates of interest?

b. Solution:

\[
\begin{align*}
\$7.85 - \$1.00 &= \$6.85, \text{ unpaid balance.} \\
\$6.85 \times .10 &= \$0.685, \text{ or } \$0.69, \text{ carrying charge.} \\
\$6.85 + \$0.69 &= \$7.54, \text{ amount to be paid.} \\
\$7.54/6 &= \$1.26, \text{ monthly payment.}
\end{align*}
\]

\[A = R\left(\frac{a_{12}}{m} \text{ at } j/m\right)\]

\[\$6.85 = \$1.26\left(\frac{a_{12}}{12} \text{ at } j/12\right)\]

\[\frac{a_{12}}{12} \text{ at } j/12 = 5.43650794\]

Solving for \( j/12 \) by interpolation:

\[
\begin{align*}
\text{When } j/12 &= 2\% \quad \frac{a_{12}}{12} = 5.46236678 \quad (1) \\
\text{When } j/12 &= 3\% \quad \frac{a_{12}}{12} = 5.43650794 \quad (2) \\
\text{When } j/12 &= 3\% \quad \frac{a_{12}}{12} = 5.41719144 \quad (3) \\
\text{Diff. of } (1) \text{ and } (2) &= .02585384 \\
\text{Diff. of } (1) \text{ and } (3) &= .04517534
\end{align*}
\]

\[j/12 = 2\% + \left(\frac{2585384}{45175334}\right)\% \]

\[= .0275 + .00143 \]

\[= .028993\]

\[j = 34.716\%, \text{ nominal rate, } m = 12.\]

Solving for the effective rate:

\[\begin{align*}
\text{Diff. of } (1) \text{ and } (2) &= (1 + j/12)^{12} \\
\text{Diff. of } (1) \text{ and } (3) &= (1.02893)^{12} \\
\log(1 + 1) &= 12 \log(1.02893) \\
&= 12(.0123859)
\end{align*}\]
\[ (1 + i) = 1.40809 \]
\[ i = 40.809\%,\ \text{effective rate.} \]

c. Problem No. 11: An electric washing machine was purchased for $195.00 with a $20.00 cash payment. The customer was permitted to pay the balance in eleven additional monthly payments. A carrying charge of 7\% of the unpaid balance was added. How much was paid and what are the nominal, \( m = 12 \), and effective rates of interest?

d. Solution:

\[ \$195.00 - \$20.00 = \$175.00,\ \text{unpaid balance.} \]
\[ \$175.00 \times .07 = \$12.25,\ \text{carrying charge.} \]
\[ \$175.00 + \$12.25 = \$187.25,\ \text{total amount to be paid.} \]
\[ \$187.25/11 = \$17.02,\ \text{monthly payment.} \]

\[ A = R(a_{\frac{j}{12}} \text{ at } j/m) \]
\[ \$175.00 = \$17.02(a_{\frac{j}{12}} \text{ at } j/12) \]
\[ a_{\frac{j}{12}} \text{ at } j/12 = 10.28202115 \]

Solving for \( j/12 \) by interpolation:

When \( j/12 = 1 \ 1/8\%, \ a_{\frac{j}{12}} = 10.29231832 \) \hspace{1cm} (1)
When \( j/12 = ? \) \hspace{1cm} a_{\frac{j}{12}} = 10.28202115 \hspace{1cm} (2)
When \( j/12 = 1\frac{1}{4} \) \hspace{1cm} a_{\frac{j}{12}} = 10.21780337 \hspace{1cm} (3)

Diff. of (1) and (2) = .01029717

Diff. of (1) and (3) = .07451495

\[ j/12 = 1 \ 1/8\% + \frac{(1029717/7451495)1/8\%}{.01125 + .00017} \]
\[ = .01125 + .00017 \]
\[ j = 13.704\%, \text{ nominal rate, } m = 12. \]

Solving for the effective rate:
\[
(1 + i) = (1 + j/12)^{12}
\]
\[ = (1.01142)^{12} \]
\[ \log(1 + i) = 12 \log(1.01142) \]
\[ = 0.059178 \]
\[ (1 + i) = 1.14599 \]
\[ i = 14.599\%, \text{ effective rate}. \]

e. Problem No. 12: A radio was bought for $200.00, with a 20% down payment, and the balance was paid in eleven equal monthly payments. A 10% finance charge was made on the unpaid balance. Find the nominal, \( m = 12 \), and effective rates of interest.

f. Solution:
\[
\$200.00 \times 0.20 = \$40.00, \text{ down payment.}
\]
\[
\$200.00 - \$40.00 = \$160.00, \text{ unpaid balance.}
\]
\[
\$160.00 \times 0.10 = \$16.00, \text{ finance charge.}
\]
\[
\$160.00 + \$16.00 = \$176.00, \text{ total amount to be paid by installment.}
\]
\[
\$176.00/11 = \$16.00, \text{ amount paid each month.}
\]

\[
A = R \left( a_{11}^{-1} \right. \text{ at } j/m)
\]
\[
\$160.00 = \$16.00 \left( a_{11}^{-1} \right. \text{ at } j/12)
\]
\[
a_{11}^{-1} \text{ at } j/12 = 10
\]
Solving for $j/12$ by interpolation:

- When $j/12 = 1\frac{1}{2}$, $a_{11} = 10.0711779$ \hspace{1cm} (1)
- When $j/12 = ?$, $a_{11} = 10$. \hspace{1cm} (2)
- When $j/12 = 1\frac{7}{8}$, $a_{11} = 9.92749181$ \hspace{1cm} (3)

Diff. of (1) and (2) = .07111779
Diff. of (1) and (3) = .14362598

\[
\frac{j/12 - 1\frac{7}{8}}{1\frac{1}{2} - 1\frac{7}{8}} = \frac{.07111779}{.14362598} = .493979
\]

\[
j/12 = 1\frac{1}{2} + (7111779/14362598)\times .493979
\]

\[
j = 19.488\%, \text{ nominal rate, } m = 12.
\]

\[
(1 + i) = (1 + j/12)^{12}
\]

\[
= (1.01624)^{12}
\]

\[
\log(1 + i) = 12 \log(1.01624)
\]

\[
= .0839556
\]

\[
(1 + i) = 1.2130
\]

\[
i = .213
\]

= 21.3\%, effective rate.

**g. Problem No. 13:** An electric refrigerator was sold for $200.00, with a down payment of 20% of the cash price. The unpaid balance was paid in eighteen payments of $10.45 per month. Find the nominal, $m = 12$, and effective rates of interest.

**h. Solution**

\[
$200.00 \times .20 = $40.00, \text{ cash payment.}
\]

\[
$200.00 - $40.00 = $160.00, \text{ unpaid balance.}
\]
\[ A = R(a_{1\bar{m}} \text{ at } j/m) \]
\[ \$160.00 = \$10.45(a_{1\bar{12}} \text{ at } j/12) \]
\[ a_{1\bar{12}} \text{ at } j/12 = 15.31100473 \]

Solving for \( j/12 \) by interpolation:

When \( j/12 = 1\frac{2}{3} \%), \( a_{1\bar{12}} = 15.32686372 \) \( (1) \)

When \( j/12 = ? \), \( a_{1\bar{12}} = 15.31100478 \) \( (2) \)

When \( j/12 = 2\% \), \( a_{1\bar{12}} = 14.99203125 \) \( (3) \)

Diff. of (1) and (2) = \( 0.01585794 \)

Diff. of (1) and (3) = \( 0.33483147 \)

\[ j/12 = 1\frac{2}{3}\% + \left(\frac{0.01585794}{0.33483147}\right) \cdot \frac{1}{12} \]
\[ = 0.0175 + 0.00012 \]
\[ = 0.01762 \]

\[ j = 0.21144 \]
\[ = 21.144\%, \text{ nominal rate, } m = 12. \]

Solving for the effective rate:
\[ (1 + i) = (1 + j/12)^{12} \]
\[ = (1.01762)^{12} \]
\[ \log(1 + i) = 12 \log(1.01762) \]
\[ = 0.0910272 \]
\[ (1 + i) = 1.23319 \]
\[ i = 0.23319 \]
\[ = 23.319\%, \text{ effective rate.} \]

i. Problem No. 14: An electric refrigerator was quoted at \$260.00 cash. The customer made a cash payment of \( 10\% \) of the cash price and chose to pay the remainder in twenty-three monthly payments. A carrying charge of \( 12\% \) of the unpaid
balance was added. What were the nominal, \( m = 12 \), and effective rates of interest paid by the customer?

j. Solution:

\$260.00 = cash price.

10\% = per cent of cash price made as down payment.

12\% = per cent added to balance as carrying charge.

\$260.00 \times .10 = \$26.00, \text{down payment.}

\$260.00 - \$26.00 = \$234.00, \text{unpaid balance.}

\$234.00 \times .12 = \$28.08, \text{interest charge.}

\$234.00 + \$28.08 = \$262.08, \text{amount to be paid by installment.}

\$262.08/23 = \$11.39, \text{monthly payment.}

\[ A = R(a_{23} \text{ at } j/m) \]

\$234.00 = \$11.39(a_{23} \text{ at } j/12)

\[ a_{23} \text{ at } j/12 = 20.54433714 \]

Solving for \( j/12 \) by interpolation:

When \( j/12 = \frac{2}{3}\% \), \( a_{23} = 21.05331473 \) \hspace{1cm} (1)

When \( j/12 = \frac{1}{2}\% \), \( a_{23} = 20.54433714 \) \hspace{1cm} (2)

When \( j/12 = 1\% \), \( a_{23} = 20.45582113 \) \hspace{1cm} (3)

Diff. of (1) and (2) = .50897759

Diff. of (1) and (3) = .59749360

\[ j/12 = \frac{2}{3}\% + \frac{(50897759/59749360) \times \frac{1}{2}}{50897759 + .0075 + .00213} \]

\[ j/12 = .0075 + .00213 \]

\[ j = .11556 \text{ or } \]

\[ j = .11556 \text{ or } \]
= 11.556\%, nominal rate, m = 12.

Solving for the effective rate:

\[(1 + i) = (1 + j/m)^m\]

\[= (1 + j/12)^{12}\]

\[= (1.00963)^{12}\]

\[
\log(1 + i) = 12 \log(1.00963)
\]

\[= 12(0.0041609)\]

\[= .0499308\]

\[1 + i = 1.12184\]

\[i = .12184\]

\[= 12.184\%, effective\ rate.\]

j. Problem No. 15: In the above problem, if the customer chose to pay the bill in seventeen monthly payments, a carrying charge of 10\% of unpaid balance would be added. What would be the nominal, m = 12, and effective rates of interest paid?

1. Solution:

\$260.00 = cash price.

10\% = per cent of cash price made as down payment.

10\% = per cent added to balance as carrying charge.

\$260.00 \times .10 = \$26.00, down payment.

\$260.00 - \$26.00 = \$234.00, unpaid balance.

\$234.00 \times .10 = \$23.40, interest charge.

\$234.00 + \$23.40 = \$257.40, amount to be paid by installments.
\[ \$257.40/17 = \$15.14, \text{ monthly payment.} \]

\[ A = R(a_{\overline{m}} \text{ at } j/m) \]

\[ \$234.00 = \$15.14(a_{\overline{17}} \text{ at } j/12) \]

\[ a_{\overline{17}} \text{ at } j/12 = 15.45574636 \]

Solving for \( j/12 \) by interpolation:

When \( j/12 = 1\% \), \( a_{\overline{17}} = 15.56252127 \) \hspace{1cm} (1)

When \( j/12 = 0 \), \( a_{\overline{17}} = 15.45574636 \) \hspace{1cm} (2)

When \( j/12 = 1 \ 1/\overline{2} \), \( a_{\overline{17}} = 15.36480360 \) \hspace{1cm} (3)

Diff. of (1) and (2) = \( .00650491 \)

Diff. of (1) and (3) = \( .00744767 \)

\[ j/12 = 1\% + (10650491/16744767)1/\overline{2} \%
\]

\[ = .01 + .00079 \]

\[ = .01079 \]

\[ j = 12.948\%, \text{ nominal rate, } m = 12. \]

Solving for the effective rate:

\[ (1 + i) = (1 + j/m)^{m} \]

\[ = (1 + j/12)^{12} \]

\[ = (1.01079)^{12} \]

\[ \log(1 + i) = 12 \log(1.01079) \]

\[ = 12(0.00488) \]

\[ = 0.05853 \]

\[ (1 + i) = 1.13742 \]

\[ i = 0.13742 \]

\[ = 13.742\%, \text{ effective rate.} \]
E. Analysis of Algebraic Process for Problems under Group B:

a. Fundamental Operations in Algebra
b. Formulas and Evaluating Formulas
c. Fractions
d. Special Products and Factoring
e. Exponents (Positive and Negative)
f. Progressions
g. Logarithms
h. Binomial Theorem

C. Short Loans

1. Morris Plan Loans. The Morris plan loans come under two headings, non collateral and collateral. The loans are payable either by weekly or monthly payments but must be paid within a year. The interest is payable in advance.

a. Collateral loans.

(I). Problem No. 16: A party borrows $800.00. $36.00 is deducted for interest, so the party receives $764.00. The monthly payments are $50.00 for twelve months. What are the nominal, m = 12, and effective rates of interest?
(II). Solution:

\[ A = R(a_{\frac{j}{m}} \text{ at } j/m) \]

\[ \$584.00 = \$50.00(a_{\frac{1}{12}} \text{ at } j/12) \]

\[ a_{\frac{1}{12}} \text{ at } j/12 = 11.28 \]

Solving for \( j/12 \) by interpolation:

When \( j/12 = \frac{3}{4\%} \), \( a_{\frac{1}{12}} = 11.43391267 \) \hspace{1cm} (1)

When \( j/12 = \% \), \( a_{\frac{1}{12}} = 11.28 \) \hspace{1cm} (2)

When \( j/12 = \% \), \( a_{\frac{1}{12}} = 11.25507747 \) \hspace{1cm} (3)

Diff. of (1) and (2) = .00491267

Diff. of (1) and (3) = .07383520

\[ j/12 = \frac{3}{4\%} + \left( \frac{15491267}{17983520} \right) \% \]

\[ = .0075 + .00215 \]

\[ = .00965 \]

\[ i = .11580 \]

\[ = 11.580\%, \text{ nominal rate, } m = 12. \]

Solving for the effective rate:

\[ (1 + i) = (1 + j/m)^m \]

\[ = (1 + j/12)^{12} \]

\[ = (1.00965)^{12} \]

\[ \log(1 + i) = 12 \log(1.00965) \]

\[ = 12(.0041695) \]

\[ = .050034 \]

\[ 1 + i = 1.12811 \]

\[ i = .12811 \]

\[ = 12.211\%, \text{ effective rate.} \]
b. Non-collateral loans.

(I). Problem NO. 17: On a loan of $100.00, $8.00 is deducted for interest and $2.00 deducted for an investigation fee, making the net amount received on the loan $92.00. The monthly payments are $8.33. Find the nominal, m = 12, and effective rates of interest paid for the loan.

(II). Solution:

\[ A = R(a_{\frac{m}{12}}) \text{ at } j/m \]

\[ $92.00 = $8.33(a_{\frac{12}{12}}) \text{ at } j/12 \]

\[ a_{\frac{12}{12}} \text{ at } j/12 = 11.04441777 \]

Solving for \( j/12 \) by interpolation:

When \( j/12 = 1\% \), \( a_{\frac{12}{12}} = 11.07831197 \) (1)

When \( j/12 = ? \), \( a_{\frac{12}{12}} = 11.04441777 \) (2)

When \( j/12 = 1\frac{1}{2}\% \), \( a_{\frac{12}{12}} = 10.90750521 \) (3)

Diff. of (1) and (2) = .03489420

Diff. of (1) and (3) = .07180676

\[ j/12 = .0125 + \left( \frac{.03489420}{.07180676} \right) .00121 \]

\[ = .0125 + .00121 \]

\[ = .01371 \]

\[ j = .16452 \]

\[ = 16.452\%, \text{ nominal rate, } m = 12. \]

Solving for the effective rate:

\[ (1 + i) = (1 + j/m)^m \]

\[ = (1 + j/12)^{12} \]

\[ = (1.01371)^{12} \]
log(1 + i) = 12 log(1.01371) 
= .0709836 
1 + i = 1.17755 
i = .17755 
= 17.755\%, \text{ effective rate.}

2. Chattel Loans. \(^8\)

a. Problem No. 18: A loan of $300.00 with interest at 3\% per month, or 42\% nominal rate, is made by a loan company. Find the effective rate of interest.

b. Solution:

\[ j = 42\% , \text{ nominal rate.} \]

Solving for the effective rate:

\[ (1 + i) = (1 + j/m)^m \]
\[ = (1 + j/12)^{12} \]
\[ = (1.035) \]
\[ \log(1 + i) = 12 \log(1.035) \]
\[ = .17928 \]
\[ 1 + i = 1.5111 \]
\[ i = .5111 \text{ or } 51.11\% , \text{ effective rate.} \]

\(^8\) 3\% per month is a State fixed rate. Loans are usually made for two or three months.
3: **Analysis of Algebraic Processes in All Problems**

under **Group C:**

a. Fundamental Operations in Algebra  
b. Formulas and Evaluating Formulas  
c. Fractions and Fractional Equations  
d. Special Products and Factoring  
e. Exponents (Positive and Negative)  
f. Progressions  
g. Binomial Theorem  
h. Logarithms

**D. Long-Period Loans**

1. **Building and Loan.** The building and loan associations differ in rates of interest charged but almost all require that the monthly payment be at least 1% of the loan. The interest rate is usually figured semi-annually upon the even $100.00. In the building and loan transactions an abstract and attorney fee is charged. This fee varies but $18.00 was found to be the usual fee. The $18.00 amounts to an additional cost to the one getting the loan; therefore it should be considered in computing the rate of interest. A table showing the various rates to be added for various sums for years one to thirteen, including the time periods over which most loans extend, is shown on the following page in Table I.
TABLE I
RATE AT WHICH $18.00 INTEREST WILL BE
OBTAINED FOR YEARS 1-13*

<table>
<thead>
<tr>
<th>Prin. $</th>
<th>% for 1 yr.</th>
<th>% for 2yrs.</th>
<th>% for 3yrs.</th>
<th>% for 4yrs.</th>
<th>% for 5yrs.</th>
<th>% for 6yrs.</th>
<th>% for 7yrs.</th>
<th>% for 8yrs.</th>
<th>% for 9yrs.</th>
<th>% for 10yrs.</th>
<th>% for 11yrs.</th>
<th>% for 12 yrs</th>
<th>% for 13 yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.00</td>
<td>18.00</td>
<td>9.00</td>
<td>6.00</td>
<td>4.50</td>
<td>3.60</td>
<td>3.00</td>
<td>2.57</td>
<td>2.25</td>
<td>2.00</td>
<td>1.80</td>
<td>1.64</td>
<td>1.50</td>
<td>1.38</td>
</tr>
<tr>
<td>500.00</td>
<td>3.60</td>
<td>1.80</td>
<td>1.20</td>
<td>0.90</td>
<td>0.72</td>
<td>0.60</td>
<td>0.51</td>
<td>0.45</td>
<td>0.40</td>
<td>0.36</td>
<td>0.33</td>
<td>0.30</td>
<td>0.28</td>
</tr>
<tr>
<td>1000.00</td>
<td>1.80</td>
<td>0.90</td>
<td>0.60</td>
<td>0.45</td>
<td>0.36</td>
<td>0.30</td>
<td>0.26</td>
<td>0.23</td>
<td>0.20</td>
<td>0.18</td>
<td>0.16</td>
<td>0.15</td>
<td>0.14</td>
</tr>
<tr>
<td>1500.00</td>
<td>1.20</td>
<td>0.60</td>
<td>0.40</td>
<td>0.30</td>
<td>0.24</td>
<td>0.20</td>
<td>0.18</td>
<td>0.15</td>
<td>0.13</td>
<td>0.12</td>
<td>0.11</td>
<td>0.10</td>
<td>0.09</td>
</tr>
<tr>
<td>2000.00</td>
<td>0.90</td>
<td>0.45</td>
<td>0.30</td>
<td>0.23</td>
<td>0.18</td>
<td>0.15</td>
<td>0.13</td>
<td>0.12</td>
<td>0.10</td>
<td>0.09</td>
<td>0.08</td>
<td>0.08</td>
<td>0.07</td>
</tr>
</tbody>
</table>

*Most loans do not extend over a period of more than 13 years.
a. Problem No. 19: A building and loan association charges 7.2% rate of interest, or 60¢ a month, on each even $100.00 or fraction thereof. Each month an amount equal to $1.20 per $100.00 of the original loan must be paid. If a man borrowed $1000.00 from this company, what were the nominal, \( n = 12\), and effective rates of interest? \( n = 121 \).  

b. Solution:

\[
A = R(a_{121}^n \text{ at } j/m)
\]

\[
R = \$1.20 \times 10 = \$12.00
\]

\[
\$1000.00 = \$12.00(a_{121}^n \text{ at } j/12)
\]

\[
a_{121}^n \text{ at } j/12 = 83.33333333
\]

Solving for \( j/12 \) by interpolation:

When \( j/12 = 7/12\% \), \( a_{121}^n \) = 86.62106602 \hspace{1cm} (1)

When \( j/12 = ? \), \( a_{121}^n \) = 83.33333333 \hspace{1cm} (2)

When \( j/12 = 8/12\% \), \( a_{121}^n \) = 79.34693822 \hspace{1cm} (3)

\[
\text{Diff. of (1) and (2)} = 3.28773289
\]

\[
\text{Diff. of (1) and (3)} = 7.27447280
\]

\[
j/12 = 7/12 + (328772282/727447280) \times 1/6\%
\]

\[
= .00583 + .00075
\]

\[
= .00658
\]

\[
j = .07896
\]

\[
= 7.896\%, \text{ nominal rate, } m = 12.
\]

---

9 \( n = 121 \) was found by making a pass book record. This lacks 40¢ of paying out, but a customer would doubtless pay the 40¢ and not let it run for another period.

As an ordinary annuity at \( 7/12 \) per period at 7.2% this would pay out in 115 or 116 months, but by this plan 121 payments are required.
Solving for the effective rate:

\[(1 + i) = (1 + j/m)^m\]
\[= (1 + j/12)^{12}\]
\[= (1.00658)^{12}\]

\[\log(1 + i) = 12 \log(1.00658)\]
\[= 12(0.00285)\]
\[= 0.03420\]

\[1 + i = 1.08193\]
\[i = 0.08193\]
\[= 8.193\%\]

Adding interest rate for the $18.00 fee for ten years:

\[8.193 + 0.18 = 8.373\%, \text{ effective rate.}\]

c. Problem No. 20: A building and loan association charged 7\%, compounded semi-annually on the even $100.00. An abstract fee of $10.00 was charged. A customer took out a loan for $1000.00, and the abstract fee was deducted from the amount he borrowed. If he pays an amount equal to 1\% of the loan each month, find the nominal and effective interest rates.

---

10 years is a little more than ten years.
d. Solution:

\[ A = R \left[ \frac{1 - (1 + i)^{-n}}{p \left( \frac{(1 + i)^{1/p} - 1}{1/p - 1} \right)} \right] - E(1 + i)^{-n} \]

Formulas 12

\[ E = \text{excess payment.} \]
\[ = \$19.00. \]
\[ w = 10 \]
\[ i = ? \]
\[ p = 6\text{mo.}/1\text{mo.} = 6 \]
\[ pw = 60 = R \]
\[ n = 27 \]
\[ A = \$1000.00 - \$10.00 = \$990.00. \]
\[ 990 = 60 \left[ \frac{1 - (1 + i)^{-27}}{(1 + i)^{1/p} - 1} \right] - 19(1+i)^{-27}. \]
\[ = 10 \left[ \frac{1 - (1 + i)^{-27}}{(1 + i)^{1/p} - 1} \right] - 19(1+i)^{-27}. \]

Let \( i = 3\frac{1}{2}\% \)

---

12D
Developed on page 39.

13
Amount which would be paid in excess of principle and interest if regular payments were continued until next conversion period. \( n = 27 \), and excess payment equals \$19.00, found by making pass book records and computing interest.

14
Since \$10.00 abstract and attorney fee was deducted, \( A \), or present value to borrower, was \$990.00.

15 \((1+i) = \left(1 + \frac{i}{p}\right)^p\)

William L. Hart, Mathematics of Investments (Chicago: D. C. Heath and Company, 1929), Tables VI & X.
\[ A = 10 \left( \frac{1 - (1.035)^{-27}}{(1.035)^{1/6} - 1} \right) - 19(1.035)^{-27} \]
\[ = 10 \left( \frac{1 - .39501224}{(1.00575004 - 1)} \right) - 19(.39501224) \]
\[ = 1052.15 - 7.51 \]
\[ = 1044.64, \text{ present value, when } i = 3\frac{1}{2}\% \]

Let \( i = 4\% \)
\[ A = 10 \left( \frac{1 - (1.04)^{-27}}{(1.04)^{1/6} - 1} \right) - 19(1.04)^{-27} \]
\[ = 10 \left( \frac{1 - .34681657}{(1.00655820 - 1)} \right) - 19(.34681657) \]
\[ = 995.68 - 6.59 \]
\[ = 989.24, \text{ present value when } i = 4\% \]

Solving for \( i \) by interpolation:

When \( i = 3\frac{1}{2}\% \), \( A = 1044.64 \) \( \text{(1)} \)
When \( i = 4\% \), \( A = 990.00 \) \( \text{(2)} \)
When \( i = 4\% \), \( A = 989.24 \) \( \text{(3)} \)

Diff. (1) & (2) = 54.64
Diff. (1) & (3) = 55.40

\[ i = 3\frac{1}{2}\% + \frac{(54.64/55.40)1\%}{2} \]
\[ = .035 + .00494 \]
\[ = .03994 \]
\[ 21\% = .07988, \text{ nominal rate, } m = 2. \]

Solving for the effective rate:
\[ (1 + i') = (1 + i)^2 \]
\[ \log(1 + i') = 2 \log(1.03994) \]
\[ = 2(.01700) \]
\[ A = \frac{R}{p} \left[ \frac{1 - (1 + i)^{-n}}{(1 + i)^{1/p} - 1} \right] \]

A = present value of an annuity.

i = interest rate per conversion period.

n = term of the annuity expressed in conversion periods.

p = number of payment intervals in each conversion period, or

\[ p = \frac{\text{interest period}}{\text{payment interval}}. \]

\[ R = p(\text{the periodic payment of the annuity}). \]

Therefore, each payment of the annuity is \( R/p \).

In terms of the symbols \((i, n, p, R)\), a problem under the simple case, \( A = R(a_n | i) \), is characterized by the fact that \( p = 1 \), because exactly one payment interval is contained in each interest period.

In the general case there are \( p \) payment intervals in each interest period; the first payment occurs at the end of \( 1/p \) periods.

the rate \( i \) per conversion period is increased to the rate \( i' \) per period.

to value of \( R \) on a day \( n \) periods before.
In Fig. 2 each division represents 1/p conversion periods with $1.00 paid each conversion period.

\[ \frac{1}{p} \quad \frac{1}{p} \quad \frac{1}{p} \quad \frac{1}{p} \quad \frac{1}{p} \quad \frac{1}{p} \]

Fig. 2. Diagram of General Annuity Formula.

By the definition of the present value of an annuity,

\[
a_{\frac{p}{n}}^n = \frac{1}{p} \left[ (1+i)^{-1/p} + (1+i)^{-2/p} + \ldots + (1+i)^{-n/p} \right]
\] (1)

\[
(1+i)^n a_{\frac{p}{n}}^n = \frac{1}{p} \left[ (1 + (1+i)^{-1/p} + (1+i)^{-2/p} + \ldots + (1+i)^{-n/p} \right]
\] (2)

Subtracting (1) from (2):

\[
(1+i)^{1/p} a_{\frac{p}{n}}^n - a_{\frac{p}{n}}^n = \frac{1 - (1+i)^{-n}}{p}
\]

\[
a_{\frac{p}{n}}^n \left[ (1+i)^{1/p} - 1 \right] = \frac{1 - (1+i)^{-n}}{p}
\]

\[
a_{\frac{p}{n}}^n = \frac{1 - (1+i)^{-n}}{p \left[ (1+i)^{1/p} - 1 \right]}
\]

\[
= \frac{1 - (1+i)^{-n}}{1 \times \frac{i}{p \left[ (1+i)^{1/p} - 1 \right]}}
\]

\[
= \frac{1}{1 \times \frac{i}{p \left[ (1+i)^{1/p} - 1 \right]}}
\]

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

To discount an amount \( E \) for \( n \) conversion periods at the rate \( i \) per conversion period means to find the present value of \( E \) on a day \( n \) periods before \( E \) is due. Let \( P = \) the present value.
\[ E = P(1+i)^n \]  
(Formula 1, page 13)

\[ P = \frac{E}{(1+i)^n} = E \left( \frac{l}{(1+i)^n} \right) = E(1+i)^{-n} \]

Deducting the present value of the excess payment the formula becomes:

\[ A = \frac{R \left[ 1 - (1+i)^{-n} \right]}{p \left[ (1+i)^{1/p} - 1 \right]} - E(1+i)^{-n} \]

f. Analysis of Algebraic Processes Used in the Solution of Building and Loan Problems:

(I). Fundamental Operations

(II). Simple or Linear Equations

(III). Fractional Equations

(IV). Special Products and Factoring

(V). Negative and Fractional Exponents (Roots and Radicals)

(VI). Binominal Theorem

(VII). Progressions

(VIII). Formulas and Evaluating Formulas

(IX). Logarithms

E. Automobiles

Automobiles bought on the installment plan are usually financed by some finance or investment company. Fire and theft insurance are usually included in the note, but this insurance is a protection to the finance company rather than to the one buying the car; therefore it will be figured as an interest cost to the customer. The finance companies
require a cash down payment of not less than 33 1/3% of the cash delivered price on new cars and not less than 40% on used cars.

1. Problem No. 21: A "Tudor" Ford Sedan was quoted at $595.00, cash. A down payment of $195.00 was made by a customer; the balance to be paid in twelve equal monthly installments. A note was made out for $445.00 to cover the unpaid balance and interest. Find the nominal and effective rates of interest. 13

2. Solution:

\[
\text{\$445.00 = amount of note.}
\]
\[
\text{\$595.00 - \$195.00 = \$400.00, unpaid balance.}
\]
\[
12\text{mo. = time of note.}
\]
\[
\text{\$445.00}/12 = \text{\$37.08, monthly payment.}
\]
\[
A = R(a_{\frac{12}{12}} at j/12)
\]
\[
\text{\$400.00} = \text{\$37.08}(a_{\frac{12}{12}} at j/12)
\]
\[
a_{\frac{12}{12}} at j/12 = 10.78748652
\]

Solving for j/12 by interpolation:

When j/12 = 1\%, a_{\frac{12}{12}} = 10.90750521

(1)

When j/12 = ?, a_{\frac{12}{12}} = 10.78748652

(2)

When j/12 = 14%, a_{\frac{12}{12}} = 10.73954962

(3)

Diff of (1) and (2) = .12001869

Diff. of (1) and (3) = .16795552

Approximate figures were given here; therefore the rate is probably lower than the actual rate.
\[
\frac{j}{12} = 1 \% + \left(\frac{12001869}{16795552}\right) \frac{j}{12}
\]

\[
= 0.015 + 0.00179
\]

\[
= 0.01679
\]

\[
j = 0.20148
\]

\[
= 20.148\%, \text{ nominal rate, } m = 12.
\]

Solving for the effective rate:

\[
(1 + i) = (1 + \frac{j}{m})^m
\]

\[
= (1 + \frac{j}{12})^{12}
\]

\[
= (1.01679)^{12}
\]

\[
\log(1 + i) = 12 \log(1.01679)
\]

\[
= 0.08676
\]

\[
(1 + i) = 1.22114
\]

\[
i = 0.22114
\]

\[
= 22.114\%, \text{ effective rate.}
\]

3. Problem No. 22: A Chevrolet coach was quoted at $593.00, cash. A payment of $198.00 was made, and the customer finished paying for the car with twelve monthly payments of $46.00 each. What were the nominal, \(m = 12\), and effective rates of interest?

4. Solution:

\[
$593.00 - $198.00 = $395.00 \text{ amount of balance.}
\]

\[
A = R\left(a_{12}^{-1}\right) \text{ at } j/12
\]

\[
\text{cash price is } \quad $395.00 = $46.00\left(a_{12}^{-1}\right) \text{ at } j/12
\]

\[
\text{then eight months} \quad \left(a_{12}^{-1}\right) \text{ at } j/12 = 8.58695652
\]

Solving for \(j/12\) by interpolation:
When \( j/12 = 5\frac{1}{2}\% \), \( a_{\frac{1}{12}} = 8.61851785 \) \hspace{1cm} (1)

When \( j/12 = ? \), \( a_{\frac{1}{12}} = 8.58625652 \) \hspace{1cm} (2)

When \( j/12 = 6\% \), \( a_{\frac{1}{12}} = 8.38384394 \) \hspace{1cm} (3)

Diff. of (1) and (2) = .03156133

Diff. of (1) and (3) = .23467391

\[
j/12 = 5\frac{1}{2}\% + \left(\frac{3156133/23467391}{2}\right) \%
\]

\[
= .055 + .00067
\]

\[
= .05567
\]

\[
j = .66804
\]

\[
= 66.804\%, \text{ nominal rate, } m = 12.
\]

Solving for the effective rate:

\[
(1 + i) = (1 + \frac{j}{m})^m
\]

\[
= (1 + j/12)^{12}
\]

\[
= (1.05567)^{12}
\]

\[
\log(1 + i) = 12 \log(1.05567)
\]

\[
= 12(.02352)
\]

\[
= .28224
\]

\[
i = .91530
\]

\[
= 91.530\%, \text{ effective rate.}
\]

5. Problem No. 23: A 1929 used Ford Sedan was sold for $165.00. The customer paid $65.00 or at least 40% of cash price as down payment and paid the balance in not more than eight monthly payments. To finance this, the note for the unpaid balance and interest was $130.00 + 1\% of $165.00.\footnote{For used Fords and used commercial trucks add 1\% of the cash delivered price to printed charge shown in finance chart.}
Find the nominal, \( m = 12 \), and effective rates of interest.

6. Solution:

\$165.00 = \text{cash price of car.}

\$165.00 \times .01 = \$1.65, \text{amount to be added to}

\$130.00 \text{note.}

\$130.00 + \$1.65 = \$131.65, \text{amount of note.}

\$131.00/8 = \$16.46, \text{monthly payment.}

\$100.00 = \text{present value of note.}

\[ A = R \left( \frac{a_{12}}{m} \right) \]

\$100.00 = \$16.46 \left( \frac{a_{12}}{m} \right)

\[ a_{12} \text{ at } j/12 = 6.07533414 \]

Solving for \( j/12 \) by interpolation:

When \( j/12 = 6\frac{1}{2}\% , \quad a_{12} = 6.06875093 \quad (1) \)

When \( j/12 = ? \quad a_{12} = 6.07533414 \quad (2) \)

When \( j/12 = 7\% , \quad a_{12} = 5.97129851 \quad (3) \)

Diff. of (1) and (2) = \$0.001341682

Diff. of (1) and (3) = \$0.11745245

\[ j/12 = 6\frac{1}{2}\% + \frac{(1.06557 - 1.06557) \times 7}{5.97129851 - 6.06875093} \]

\[ j/12 = 6\frac{1}{2}\% + \frac{0.00057}{0.097458} \]

\[ j/12 = 6\frac{1}{2}\% + 0.0057 \]

\[ j = 0.06557 \]

\[ j = 78.684\% , \text{nominal rate, } m = 12. \]

Solving for the effective rate:

\[ \text{Diff. of (1) } (1 + i) = (1 + j/m)^m \]

\[ i = (1 + j/12)^{12} \]

\[ i = (1.06557)^{12} \]
\[
\log(1 + i) = 12 \log(1.06557) \\
= 12(0.027582) \\
= 0.330984 \\
1 + i = 2.14281 \\
i = 1.14281 \\
= 114.281\%, \text{ effective rate.}
\]

7. Problem No. 24: A series "A", 1930 delux line, 4-door, Ford sedan was sold for $270.00. The customer paid $110.00 cash and the balance in twelve monthly payments. The note was made out for $200.70. Find the nominal, \( m = 12 \), and effective rates.

8. Solution:

\[
\frac{270.00 - 110.00}{200.70} = \frac{160.00}{12}, \text{ unpaid balance.} \\
\frac{200.70}{12} = \text{amount of note.} \\
\frac{200.70}{12} = \frac{16.73}{1}, \text{ monthly payment.} \\
A = R \left( a_{12} \text{ at } j/m \right) \\
160.00 = 16.73 \left( a_{12} \text{ at } j/12 \right) \\
a_{12} \text{ at } j/12 = 9.56366809
\]

Solving for \( j/12 \) by interpolation:

When \( j/12 = 3\% \), \( a_{12} = 9.36333433 \)  
When \( j/12 = 4\% \), \( a_{12} = 9.36507376 \)

\[
\text{Diff. of (1) and (2)} = 0.001724 \\
\text{Diff. of (1) and (3)} = 0.27826057
\]

\[
j/12 = 3\% + (0.001724/0.27826057)1\% \\
= 0.035 + 0.00173
\]
Solving for the effective rate:

\[(1 + i) = (1 + j/m)^m\]
\[= (1 + j/12)^{12}\]
\[= (1.03679)^{12}\]
\[\log(1 + i) = 12 \log(1.03679)\]
\[= 12(.0156908)\]
\[= .1882896\]
\[1 + i = 1.54272\]
\[i = .54272\]
\[= 54.272\%\], effective rate.

9. Problem No. 25: A Marmon "8-125 Standard", quoted at \$1495.00, cash price, was sold to a customer who made a down payment of \$520.00 and paid the remainder in twelve monthly payments. The note was made for \$1131.00. Find the nominal, \(m = 12\), and effective rates of interest.

10. Solution:

\[
\$1495.00 - \$520.00 = \$975.00, \text{ unpaid balance.}
\]
\[
\$1131.00 = \text{amount of note.}
\]
\[
\$1131.00/12 = \$94.35, \text{ monthly payment.}
\]
\[
A = R(a_{12} at j/m)
\]
\[
\$975.00 = \$94.25(a_{12} at j/12)
\]
\[
a_{12} at j/12 = 10.34482759
\]
Solving for \( j/12 \) by interpolation:

When \( j/12 = 2\% \), \( a_{12} = 10.41477882 \) \( \quad (1) \)

When \( j/12 = ? \), \( a_{12} = 10.34482769 \) \( \quad (2) \)

When \( j/12 = 2\frac{1}{2} \% \), \( a_{12} = 10.25778460 \) \( \quad (3) \)

Diff. of (1) and (2) = 0.06995123

Diff. of (1) and (3) = 0.15701422

\[
j/12 = 2\% + \frac{(0.06995123/0.15701422) \times 12}{12} = 0.0225 + 0.00111 = 0.02361
\]

\[
j = 28.332 \%
\]

Solving for the effective rate:

\[
(1 + i) = (1 + j/m)^m
\]

\[
= (1 + j/12)^{12} = (1.02361)^{12}
\]

\[
\log(1 + i) = 12 \log(1.02361) = 12(0.0101345) = 0.121616
\]

\[
i = 0.32316
\]

\[
i = 32.316\%, \text{ effective rate.}
\]

11. Analysis: These problems involve fundamental operations in algebra, formula, evaluating formulas, fractions, special products and factoring, exponents, progressions, logarithms, and the use of tables.
F. Delinquent Taxes on Home and Personal Property

The failure to pay the May installment of taxes renders taxes for the entire year delinquent. A penalty of ten percent of the taxes is added; then, if the taxes are not paid before the following February, the property is put up for sale, making the interest period nine months. If there is any charge in the collection, this charge is also added; so the rate of interest will usually be higher than that computed.

1. Problem No. 26: The May installment of taxes on a piece of property is $66.68, and the owner lets it go delinquent. Find the rate of interest paid for delinquency.

2. Solution:

$66.68 \times 2 = \$133.36$, amount of taxes.

$133.36 \times .10 = \$13.34$, charge for delinquency.

9 mo. = interest period for 1st $66.68.

3 mo. = interest period for 2nd $66.68.

$I = Prt.$

$66.68 \times 1 \times r/100 = \$13.34$

$r = .20006$

$= 20.006\%$, effective rate.

---

18 This study was made before the present tax rulings were made.
G. Summary of Interest Rates

Table II shows the effective rates of interest paid in transactions that are essential in a home and in home owning. The rates vary from 8.105% on building and loan to 723.21% on the delinquent electric bill. In problem number eight and problem number nine it will be noticed that the rates on furnaces vary from 10.575% to 21.305%. In problems number thirteen through fifteen the rates of interest paid in installment buying of electric refrigerators vary from 12.184% to 23.312%. Problems number twenty-two through twenty-six show that for automobiles the rates vary from 22.114% to 114.28%. A median of 21.709% is found, or half of the rates of interest in financial transactions of ordinary home management come above 22%.
### TABLE II

**SUMMARY OF EFFECTIVE RATES OF INTEREST PAID IN ORDINARY FINANCIAL TRANSACTIONS OF HOME MANAGEMENT**

<table>
<thead>
<tr>
<th>Problem No.</th>
<th>Type of Problem</th>
<th>Effective rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Delinquent Gas Bill</td>
<td>519.480</td>
</tr>
<tr>
<td>2</td>
<td>Delinquent Water Bill</td>
<td>400.000</td>
</tr>
<tr>
<td>3</td>
<td>Delinquent Electric Bill</td>
<td>723.210</td>
</tr>
<tr>
<td>4</td>
<td>Delinquent Electric Bill</td>
<td>452.690</td>
</tr>
<tr>
<td>5</td>
<td>Delinquent Electric Bill</td>
<td>600.000</td>
</tr>
<tr>
<td>6</td>
<td>Furniture</td>
<td>15.376</td>
</tr>
<tr>
<td>7</td>
<td>Used Piano</td>
<td>27.740</td>
</tr>
<tr>
<td>8</td>
<td>Furnace</td>
<td>10.575</td>
</tr>
<tr>
<td>9</td>
<td>Furnace</td>
<td>21.305</td>
</tr>
<tr>
<td>10</td>
<td>Electric Iron</td>
<td>40.809</td>
</tr>
<tr>
<td>11</td>
<td>Electric Washing Machine</td>
<td>14.599</td>
</tr>
<tr>
<td>12</td>
<td>Radio</td>
<td>21.300</td>
</tr>
<tr>
<td>13</td>
<td>Electric Refrigerator</td>
<td>23.319</td>
</tr>
<tr>
<td>14</td>
<td>Electric Refrigerator</td>
<td>12.184</td>
</tr>
<tr>
<td>15</td>
<td>Electric Refrigerator</td>
<td>13.742</td>
</tr>
<tr>
<td>16</td>
<td>Short Collateral Loan</td>
<td>12.211</td>
</tr>
<tr>
<td>17</td>
<td>Short Non-collateral Loan</td>
<td>17.755</td>
</tr>
<tr>
<td>18</td>
<td>Chattel Loan</td>
<td>51.110</td>
</tr>
<tr>
<td>19</td>
<td>Building and Loan</td>
<td>8.105</td>
</tr>
<tr>
<td>20</td>
<td>Building and Loan</td>
<td>8.143</td>
</tr>
<tr>
<td>21</td>
<td>New Ford Sedan</td>
<td>22.114</td>
</tr>
<tr>
<td>22</td>
<td>New Chevrolet Coach</td>
<td>91.530</td>
</tr>
<tr>
<td>23</td>
<td>Used Ford 1929</td>
<td>114.281</td>
</tr>
<tr>
<td>24</td>
<td>Used Ford 1930</td>
<td>54.272</td>
</tr>
<tr>
<td>25</td>
<td>New Marmon</td>
<td>32.313</td>
</tr>
<tr>
<td>26</td>
<td>Delinquent Taxes</td>
<td>20.006</td>
</tr>
</tbody>
</table>

**Median** 21.709
It is necessary to have certain furniture and equipment. Sometimes the money is not available when needed, making it necessary to purchase on the installment plan, but many times the purchase could be deferred until sufficient savings could be accumulated to make it possible to purchase on a cash basis. Before making an investment the purchaser should consider whether the immediate need is worth the price that must be paid for the services of installment buying. In the group for home-equipment buying the rates varied from 10.575% to 40.809%, all high rates of interest; yet 95% of all such purchases are made on the installment plan.

The building and loan rates are more conservative, probably because of the security of the property. Also, a building and loan is, in theory, a stock company and is presumably a co-operative enterprise. The rates are higher than the quoted rates because interest is charged on the even $100.00.

The rates of interest paid for installment buying of automobiles are very high. The purchaser should consider carefully the value of the purchase to himself, and whether the need justifies paying the high rates charged for installment buying. In this group, the rates varied from 22.114% to 114.281%.
Not less than a third of the cash value of a car must be made as down payment. Forty per cent of the cash price must be made as down payment on used cars. This amount placed in a savings bank, with the monthly payments put into savings, would accumulate so that in a short time cash could be paid. For example, take problem No. 22 on page 43:

1. Problem A: \$593.00 was the cash price of the car; a cash payment of \$198.00 was made and the customer finished paying for the car with twelve monthly payments of \$46.00 each. A savings bank pays three per cent interest compounded semi-annually on amounts that have been deposited at least three months at the time the interest is computed. \$198.00 placed in the bank for six months will amount to \$198(1 + .015)^1$, but full interest can not be received for at least nine months or until the end of the conversion period after last deposit has been made.

\[ A = P(1 + r)^k \]

\[ \$198(1 + .015)^1 = \$200.97, \text{ value of cash payment with} \]

interest for six mo.

\[ \$593.00 - \$200.97 = \$393.03, \text{ balance which must be} \]

accumulated.

\[ S = \text{the amount of an annuity.} \]

\[ S = \frac{R (1+ i)^n - 1}{p (1+i)^{1/p} - 1} \]

\[ w = \$46.00, \text{ monthly deposit.} \]

\[ p = 6 \text{ mo.}/1 \text{ mo.} = 6 \]
\[ R = pw \text{ or } \$46.00 \times 6 \]
\[ = \$276.00, \text{ deposits per conversion period.} \]
\[ n = \text{number of conversion periods.} \]

\[ s_n \text{ at } i = \$393.03 \]
\[ \frac{\$393.03 - 276(1.015)^n}{1/(1.015)^{1/6} - 1} \]
\[ = \frac{46 (1.015)^n - 1}{1.00248452 - 1} \]

\[(1.015)^n - 1 = .021228 \]
\[(1.015)^n = 1.021228 \]
\[ n \log 1.015 = \log 1.021228 \]
\[ .00647n = .00913 \]
\[ n = \frac{.00913}{.00647} \]
\[ n = 1.411 \]
\[ 1.411 \times 6 = 8.466, \text{ number of monthly deposits necessary to accumulate } \$393.03. \]

The last monthly payment would have to be in the bank for at least three months to draw interest. For full interest to be drawn, the purchaser would have to wait at least a year to make the purchase, but he would be saving over three and one half payments of \$46.00, or \$161.00 plus at least three months' interest on the whole \$593.00. Is the use of the car going to be worth more than \$161.00 as an investment? This is the question that should be asked and answered by the individual making the purchase.
Attention is called to the fact that the writer is not advocating the abolition of credit. If money was never borrowed at reasonable rates of interest, there would be no reason for financial institutions paying interest on savings accounts. However, in the case of installment buying in home management, the rates of interest charged are seldom reasonable. Installment buying could well be discouraged without effecting the ordinary credit system in sound business finance.

2. Problem B: Consider the same problem as above, depositing savings in a building and loan association with interest at 5% compounded semi-annually.

\[ A = P(1+r)^t \]

\$198(1.025)^1 = \$202.95, value of cash payment with six mo. interest.

\$593.00 - \$202.95 = \$390.05, balance to be accumulated.

Solving by the method used by the Building and Loan Associations: 19

\$46.00 \times 0.025 \times 21/6 = \$4.025, simple interest on monthly payments for one conversion period.

\$46.00 \times 6 = \$276.00, deposited in six months.

\$276.00 + \$4.025 = \$280.025, accumulated value of deposits with interest for one conversion period.

---

19 William L. Hart, Mathematics of Investments (Chicago: D.C. Heath and Company, p.109, Example 1. The equivalent in single months for which the monthly deposits draw interest during a conversion period is \((6 + 5 + 4 + 3 + 2 + 1)\), or 21.
Applying the formula for the amount of an annuity:

\[ s = R(s_m \text{ at } i) \]

\[ \$390.05 = \$280.025(s_m \text{ at } .025) \]

\[ s_m \text{ at .025} = 1.39294706 \quad (1) \]
\[ s_1 \text{ at .025} = 1.00000000 \quad (2) \]
\[ s_3 \text{ at .025} = 2.02500000 \quad (3) \]

Diff. of (1) and (2) = 0.39294706

Diff. of (2) and (3) = 1.02500000

\[ n = 1 + \left( \frac{39294706}{102500000} \right) \]
\[ = 1.38337 \]

Each conversion period has six months, therefore,

\[ 1.38337 \times 6 = 8.30022, \text{ or 8 1/3 deposits are} \]

necessary to accumulate the amount of balance necessary for

cash payment.

\[ 12 - 8 \ 1/3 = 3/3/3; \text{ payments saved.} \]

\[ \$46.00 \times 3 \ 2/3 = \$168.67, \text{ calculated saving to be} \]

expected by accumulating enough to pay cash. However, the

deposits will not draw interest for the second conversion

period unless they are left in until the end of the period,

at which time the accumulated saving will amount to:

\[ \$168.67 + (\text{six mo. interest on } \$202.95) + (\text{interest from time} \]

of last payment until the end of the period, on the rest of

the amount which is on deposit, or on \$46.00 \times 8 1/3.

3. Development of \(s_m\) at \(i\) Simple Formula:

If interest is at the rate \(i\) per period, \(s_m\) the

amount of an annuity, \((s_m \text{ at } i)\), or \(s_m \times i\), represents
the amount of an annuity of $1.00 per interest period for \( n \) periods.

In Fig. 3 each division represents a conversion period, and the arrows indicate the periods of accumulation for each payment.

By the definition of the amount of an annuity,

\[
\frac{s_n}{n} = 1 + (1+i) + (1+i)^2 + (1+i)^3 + \ldots + (1+i)^{n-1} \quad (1)
\]

\[
(1+i)\frac{s_n}{n} = (1+i) + (1+i)^2 + \ldots + (1+i)^n \quad (2)
\]

Subtracting (1) from (2):

\[
(1+i)\frac{s_n}{n} - \frac{s_n}{n} = (1+i)^n - 1
\]

\[
\frac{s_n}{n} = (1+i)^n - 1
\]

The general formula used in the first example can be developed in the same way, fractional exponents being used instead of integral exponents.

4. Analysis of Algebraic Processes Used in Solution of Problem and Development of Formula: The problem involves the fundamental operations of algebra, the formula,
and evaluating formulas, simple equations, fractional equations, special products and factoring, binomial theorem, logarithms, and positive exponents.

I. Summary of Analyses of Mathematical Processes

The following topics cover the algebraic processes used in the solution of the problems and development of the formulas used in Chapter II:

1. Fundamental Operations
2. Formulas and Evaluating Formulas
3. Simple or Linear Equations
4. Fractions and Fractional Equations
5. Special Products and Factoring
6. Binomial Theorem
7. Progressions
8. Logarithms
9. Exponents: Positive, Negative, and Fractional (or Roots and Radicals)
III. ANALYSIS OF SECOND-COURSE ALGEBRA TEXTS FOR TOPICS
PREREQUISITE TO HOME-MANAGEMENT MATHEMATICS

A. Books Analyzed

An analysis of thirteen, modern, second-course algebra texts was made to determine how much of the subject matter dealt with topics used in the computation of problems in the thesis. These texts were submitted for state adoption in 1933, therefore representing the typical work in algebra given in high school.

The topics checked were those listed in the Summary of Analysis of Chapter II of the thesis. Radicals and roots were included, for a knowledge of these topics is essential to the understanding of fractional exponents.

The analyses of these texts are found in the following pages.
Book No. 1.


<table>
<thead>
<tr>
<th>Topic</th>
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<tbody>
<tr>
<td>1. Fundamental Operations</td>
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<tr>
<td>2. Formulas and Evaluating of Formulas</td>
<td>7</td>
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<tr>
<td>3. Simple or Linear Equations</td>
<td>13</td>
</tr>
<tr>
<td>4. Fractions and Fractional Equations</td>
<td>25</td>
</tr>
<tr>
<td>5. Special Products and Factoring</td>
<td>20</td>
</tr>
<tr>
<td>6. Binomial Theorem</td>
<td>11</td>
</tr>
<tr>
<td>7. Progressions</td>
<td>20</td>
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<tr>
<td>8. Logarithms</td>
<td>19</td>
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<tr>
<td>9. Exponents: Positive, Negative, and Fractional (or Roots and Radicals)</td>
<td>20</td>
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Total Number Pages in Book 251

Total Number Pages Devoted to Topics

Prerequisite to Home-Management Mathematics 154
Book No. 2.


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<td>2. Formulas and Evaluation of Formulas</td>
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<tr>
<td>3. Simple or Linear Equations</td>
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<td>4. Fractions and Fractional Equations</td>
<td>7</td>
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<tr>
<td>5. Special Products and Factoring</td>
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<td>6. Binomial Theorem</td>
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Total 70

Total Number Pages in Book 141

Total Number Pages Devoted to Topics Prerequisite to Home-Management Mathematics 70
Book No. 3.


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<td>2. Formulas and Evaluating Formulas</td>
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<tr>
<td>3. Simple or Linear Equations</td>
<td>9</td>
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<tr>
<td>4. Fractions and Fractional Equations</td>
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<tr>
<td>5. Special Products and Factoring</td>
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<td>6. Binomial Theorem</td>
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Total 122

Total Number of Pages in Book 280

Total Number of Pages Devoted to Topics Prerequisite to Home-Management Mathematics 122
Book No. 4.

Longley, William Raymond, and Harsh, Harry Brooks,

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<td>4. Fractions and Fractional Equations</td>
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<td>5. Special Products and Factoring</td>
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<td>8. Logarithms</td>
<td>25</td>
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<tr>
<td>9. Exponents: Positive, Negative, and</td>
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<td>Fractional (or Roots and Radicals)35</td>
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Total Number of Pages in Book 414

Total Number of Pages Devoted to Topics Pre-requisite to Home-Management Mathematics 232
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<td>2. Formulas and Evaluating of Formulas</td>
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<tr>
<td>3. Simple or Linear Equations</td>
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</tr>
<tr>
<td>4. Fractions and Fractional Equations</td>
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<tr>
<td>5. Special Products and Factoring</td>
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<td>6. Progressions</td>
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<td>7. Binomial Theorem</td>
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<tr>
<td>8. Logarithms</td>
<td>18</td>
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<tr>
<td>9. Exponents: Positive, Negative, and Fractional</td>
<td>32</td>
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<tr>
<td>(or Roots and Radicals)</td>
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Total Number Pages in Book

Total Number Pages Devoted to topics Prerequisite to Home-Management Mathematics

245

121
Book No. 6.


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<tr>
<td>4. Fractions and Fractional Equations</td>
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<td>5. Special Products and Factoring</td>
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<td>6. Binomial Theorem</td>
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<td>9. Exponents: Positive, Negative, and Fractional (or Roots and Radicals)</td>
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Total Number Pages in Book 400

Total Number Pages Devoted to Topics Prerequisite to Home-Management Mathematics 216
Book No. 7.


Topics

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<td>7.</td>
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<td>8.</td>
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Total Number Pages in Book  400

Total Number Pages Devoted to Topics Prerequisite to Home-Management Mathematics  247
Book No. 8.


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<td>4. Fractions and Fractional Equations</td>
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<td>5. Special Products and Factoring</td>
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Total Number Pages, Not Including Review 472

Total Number Pages Devoted to Topics Prerequisite to Home-Management Mathematics 221
Book No. 9.


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Total Number Pages of Book 472

Total Number Pages Devoted to Topics Prerequisite to Home-Management Mathematics 305
Book No. 10.


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Total Number Pages in Book 425

Total Number Pages Devoted to Topics Prerequisite to Home-Management Mathematics 224
Book No. 11.

Wells, Webster, and Hart, Walter, *Second Book in Algebra.*


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Total Number Pages in Book: 252

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Total Number Pages in Book: 333

Total Number Pages Devoted to Topics Prerequisite to Home-Management Mathematics: 130
Book No. 13.


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Total                              98

Total Number Pages in Book         142

Total Number Pages Devoted to Topics Prerequisite to Home-Management Mathematics 98
### TABLE III

**TEXTS ANALYZED AND PAGES DEVOTED TO TOPICS PREREQUISITE TO HOME-MANAGEMENT MATHEMATICS: A SUMMARY**

<table>
<thead>
<tr>
<th>Text</th>
<th>Author</th>
<th>Pages</th>
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<tbody>
<tr>
<td>Second Course in Algebra</td>
<td>Nyberg</td>
<td>154</td>
</tr>
<tr>
<td>A Second Course in Algebra</td>
<td>Newell and Harper</td>
<td>70</td>
</tr>
<tr>
<td>Bobbs—Herrill Algebra _Book II</td>
<td>Krickenberger, Whit-</td>
<td>122</td>
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<td>craft &amp; Welchons</td>
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<td>Algebra--Book II</td>
<td>Longley and Marsh</td>
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<td>Second Course in Algebra</td>
<td>Williams and Taylor</td>
<td>121</td>
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<td>Engelhardt and Haertter</td>
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<td>Stone and Mallory</td>
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<td>130</td>
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<td>Second Year Algebra</td>
<td>Rothrock</td>
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</table>

**Median Number of Pages** 154
B. Summary of Chapter III

The analyses of the second-course algebra texts showed that approximately 50% of the subject matter dealt with topics used in the computation of problems in the thesis. A total of 2,249 pages were devoted to these various topics as compared to a total of 4,257 pages devoted to all subject matter in the texts. This makes 52.83% of the subject matter devoted to topics prerequisite to home-management mathematics.
IV. CONCLUSIONS CONCERNING THE APPLICATIONS OF ALGEBRA IN HOME-MANAGEMENT FINANCE

The studies made in the preparation of this thesis have brought forth the conclusions set out below with regard to the subjects and questions stated in the introduction.

A. Need of Mathematical Knowledge in Home Management

The rates of interest paid for installment buying are high. Investigation shows that there is great variation in the financing fees and interest rates, which go to make up the total cost of an investment, charged by different financing companies. It will be noted, from the problems in Chapter II, that when the fees and service charges are added, the effective rates of interest are much higher than the percentages quoted, and vary in accordance with the method of payment. If the home manager had the mathematical knowledge for computing the amount paid for the services of installment buying, and the immediate worth of the services of the article to him, he might be able to save large sums. If bills were paid on time, and, if spending for house-hold equipment was carefully done, large amounts of money would be saved.
B. The Applications of Algebra in Home-Management Transactions

Algebra is not commonly thought of in connection with ordinary home-management transactions. Yet, with a working knowledge of the algebra as used in the solution of the problems included in this thesis, it can be used to advantage in computing actual costs of fees and interests asked on various forms of loans, or profits be be derived from investments. By the use of algebra as involved in the "Mathematics of Finance", one can determine which loan or which investment is the best, or which offers the lowest effective rate of interest.

The algebraic formulas and topics used in the computation of many financial problems of home management make up the subject matter of 52.83% of the pages of the average second-course algebra text book.

In many business firms use is made of tables which, in many cases, have been prepared from the results of algebraic computations.

C. A Possible Need for a Twelfth-Grade Course in "Mathematics of Finance"

As a twelfth-grade mathematics course, the "Mathematics of Finance" would be a much more practical course for the high-school senior to elect than trigonometry or college algebra. Mathematics of finance fits the general needs of
all adults better than the traditional courses in trigonometry and college algebra.

Trigonometry is useful to an engineer or one interested in a science such as physics, and in drawing and constructing graphs of equations. Enough trigonometry is included in the first and second courses in algebra to supply the need of the science student. Therefore, the engineering and advanced mathematics students are the only ones for whom a complete course in trigonometry is necessary. The course in college algebra is more theoretical than the course in mathematics of finance and is useful only to students of higher mathematics and engineering. Hence, the course in mathematics of finance more nearly supplies the needs for solving the problems arising in the daily life of all adults in connection with home-management than do the courses now commonly given.

D. Need for Algebra and the Means for Motivating the Study of the Subject

It has been pointed out in the analyses made in Chapters II and III of this study that considerable algebra beyond the first year is necessary for a course in mathematics of finance; therefore a second course, as well as a first-year course in algebra would be a prerequisite for a course in mathematics of finance.
The second course in algebra could be offered in the first semester of the twelfth year, and "Mathematics of Finance" could be offered in the second semester, as a one-semester subject. If "Mathematics of Finance" is offered as a two-semester course then the algebra could be offered as an eleventh-year course in the second semester.
V. BIBLIOGRAPHY


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