# RELATED MATHEMATICS PROBLEMS

# FOR

# TRADE AND INDUSTRIAL EDUCATION

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By

Glenn Joachim

Bachelor of Science
Northwestern State Teachers' College
Alva, Oklahoma
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H. A. Huntington

In Charge of Thesis

H. A. Huntington

Head of the Department of Trade and Industrial Education

D. G. McIntosh

Dean of the Graduate School

# PREFACE

Several years ago, the writer, while teaching seventh grade arithmetic, noted the inability of the pupils to grasp the abstract meanings of such terms as volume, area, etc., as used in abstract problems, and an inability to relate these or to get any idea of what, say, the area of a plane figure meant. He noted also that these same pupils, upon reaching high school and beginning to specialize in particular trade work, experienced difficulty in applying abstract mathematics to practical solutions or in working out practical problems in everyday mathematics as applied to their respective trades.

In casting about for a means of remedy, the writer tried the scheme of using practical laboratory work; namely, that a student, when being taught the meaning of volume, area, and other terms, actually works with the figures whose volume he is finding, and sees that the volume of the figure means the space it contains. The problems assigned in this laboratory course are not abstract, but are selected with a desire to make practical application of the mathematics upon the trades.

There are, however, few textbooks available which make these practical applications in problems or which relate abstract problems directly to the practical work in which, after all, they will be used. It was the writer's idea, therefore, to make a compilation of some few problems which could be used to achieve the above purposes; to teach mathematics that does not end in the classroom but extends into the branches of industry and business in which they will actually be used. Such compilation is, of necessity, a long task and one which will never really be completed. Real work is rapidly being carried on in the preparation of such texts and teaching methods as are here mentioned.

The writer hopes his small contribution may aid the development of this study.

The writer wishes to acknowledge his grateful appreciation of the help and guidance extended him by H. A. Huntington and Fred Heisler. He wishes further to extend his appreciation to the Library Staff of Oklahoma Agricultural and Mechanical College and the vocational teachers and tradesmen who have been so very kind and gracious in validating the problems pertaining to the various trades.

G. J.

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# CHAPTER I

## INTRODUCTION:
## THE PLACES OF PRACTICAL PROBLEMS IN TEACHING RELATED MATHEMATICS

The writer has, for several years, noted a deficiency in mathematics of students who have gone through the regular abstract courses in high school mathematics now given. Such students, even those who have had all the mathematics offered in the high school, have trouble applying mathematics out on the job. Mathematics to them has been an impractical, blackboard proposition whose value or interest, if any, has ended when the student leaves the classroom. This situation is quite serious. Many companies are forced to hold evening classes, part of which are made up of classes in practical mathematics ---- to teach employees mathematics related to their trade or work. In many industries, it is becoming necessary for rather old men and women to take these courses in order to be eligible for advancement in their chosen line.

What is the answer to this problem? The trade classes mentioned above have answered that question for us already. The men and women who have had these practical courses are almost invariably ready for further advancement and do advance because of the better grasp on their trade an understanding of practical mathematics gives them. The question, then, is not how to do this. It is, rather, why is the practical side of mathematics neglected in educating people? Mathematics classes as taught in academic high schools ---- and most of the population today is educated in academic rather than trade schools --- are, as a rule, dry and uninteresting. They make no practical application of mathemat-

ics as the student must know it when he reaches the outside world. Mathematics as it is there taught resolves itself into a proposition of drill, drill, drill on abstract theorems and problems which many students seldom understand and in which few are interested. If the student cannot make himself interested in that science which is to be his main tool in trade or in business, he handicaps himself that much more at the start. If the teacher in high school can help the student learn practical, related mathematics and become interested in it, he has helped the student one notch higher in his drive toward success. To do this, however, considerable portions of the present courses in mathematics cannot be used. Mathematics should be taught more from a practical standpoint rather than a theoretical standpoint. The traditional methods of working problems in which the student is given all conditions and theorems ready-made should be altered to give the student practical experience in discovering conditions and interpreting them. Once he understands the real why of a certain proposition as he will use it on the job, he will be able to reason from that to other conclusions, and will have mastered much more knowledge from a little practical mathematics than he could from a great deal of theoretical, abstract mathematics.

THE METHOD OF TEACHING RELATED MATHEMATICS:

To accomplish the ends above stated, we must have a new treatment of mathematics which teaches the practical side. This new treatment presupposes that we have a new material, written from a practical standpoint both in discussion and in actual practise problems. Problems and discussions which might be used in this sort of course are given in the body of this thesis; but the list is, necessarily, not complete and will

admit of much expansion and specialization in different occupational fields. Problems are here compiled for the special fields of woodwork, metal work and electricity, including fundamentals of practical mathematics needed in these fields as well as more advanced material. It should be remembered, however, that the average mathematics teacher is not qualified to teach related trade subjects themselves. The related mathematics teacher is expected to teach his pupils the mathematics they will need to know in their respective lines of life work.

This material should be taught more from a laboratory standpoint rather than an abstract one. Assuming that we have the problems we wish to teach selected, let the student then attack them in a sort of 'laboratory' setting and discover the conditions which hold in the proposition at hand, and reason out, with judicious assistance from the instructor, the means of solution for the problems.

Let it be fully understood, however, that abstract problems will be of little or no value in a course in mathematics taught from the laboratory or actual experience standpoint. Not only the method of teaching, but the situations taught, should be practical and related directly to fundamental experience. Present texts may be used, but the instructor should supply sufficient concrete laboratory practise to make sure that the student really learns the needed essentials rather than secures a hazy, fleeting notion of the material gone over. Student interest in the subject being taught should be maintained through problems the student is able to work himself, while keeping sufficiently within bounds to assure the learning of all the really needed fundamentals. This assured, the success of the plan is secured; for, if the student is really interested in his work, he will learn; if he learns, his knowledge is perman-

ent and practical and will stay with him in usable form throughout his life. That is, after all, the purpose of this study.

# CHAPTER II

## FUNDAMENTALS OF ARITHMETIC

Arithmetic, the most commonly used of the mathematical sciences, is defined as that branch of mathematics which has for its symbols or language Arabic numbers, as: 1234567890. Using these numerals, representations of quantity, size, time, and so on may be made. Various operations may be performed on these representations in order to symbolize arithmetically actual working conditions of a problem. These operations fall under four headings; (1) Addition (2) Subtraction (3) Multiplication and (4) Division. These four operations or multiples or combinations of them make up arithmetic. The following information and practical exercises are recommended for review purposes only, since one needs a clearer understanding of these fundamentals.

### ADDITION

Addition is the process of uniting two or more numbers representing groups of objects of the same kind. The numbers (or things) to be added are called addends. The number (or group) obtained by adding two or more numbers is called the sum and represents one large group of similar objects, the quantity of which is equal to that of the component groups. The symbol + is the sign of addition and is called "plus".

Illustrative problem:

Add the following numbers: 609, 24 and 15.

Solution

609 )
24 ) --- Addends
15 )
648 ) --- Sum

Illustrative problems in addition:

| 1. | 2. | 3. | 4. |
|---|---|---|---|
| 54 | 459 | 4598 | 35876 |
| 49 | 907 | 345 | 534 |
| 16 | 113 | 1027 | 8945 |
| 90 | 549 | 43 | 83902 |
| 34 | 238 | 172 | 108 |
| 27 | 620 | 2119 | 2437 |

5. Add the following numbers:
Nine thousand eight hundred and twenty-four.
Six hundred and thirty eight.
Fourteen thousand two hundred and two.
Twenty-five thousand.
Fifty-five.

6. Add the following numbers:
One thousand, nine hundred thirty seven.
Three hundred and forty-eight.
Ninety-seven.
One thousand nine hundred and eighteen.

7. What is the sum of 604 and Seven hundred and twenty-eight.

8. The monthly output of a shop manufacturing castings was as follows: January, 8,509; February, 9,765; March, 6,564; April, 11,876; May, 15,672; June 15,300. What was the total output during the six months?

9. In problem 8, what was the output during the first three months? During the last three?

10. A boy works 3 2/3 hours on one job, 1 3/4 on another, and 2 5/12 hours on a third. What is the total time he worked in hours?

11. Add the following numbers: 23.54, .008, 39.4, 2.08, 920.005.

12. Add the following numbers: thirteen and one-tenth, five hundred thirty and twenty-three hundredths, five-thousandths, eight hundred and twenty-three thousandths, five hundred and seventy.

13. Add the following fractions: 5/6, 2/3, and 3/12.

14. Add the following numbers: One and one-sixth, four-sevenths, thirteen and three-eighths.

13. 1324.50 + 34.872

14. 34.987 + 1.008

15. .9478 + .5580

16. A piece of wood 3 1/16 inches thick was planed down to 3 1/8 inches thick. What thickness of the board was removed?

17. A block of steel 3.0625 inches thick is cut down to a thickness of 2.9375 inches. What thickness of the metal is removed?

18. An electric light meter registers 8,768 watt-hours at one reading, and 9,210 at the next reading; how many watt-hours of electricity were used by the customer between readings?

## MULTIPLICATION

Multiplication is a process of taking one of two given numbers as many times as there are units in the other number. The number which is multiplied or increased is called the multiplicand. The multiplier is the number by which the multiplicand is multiplied. The resultant number is called the product. The sign of multiplication is "X" and is called "times".

Problems illustrating multiplication:

Multiply 125 by 8.

Solution:

125 --- multiplicand
8 --- multiplier
1000 --- product

Problems on multiplication;

1. Multiply 865 by 27.
2. Multiply 1565 by 523.
3. Multiply 467 by 12 1/2.
4. Multiply 107 times 3060.
5. Multiply 3 1/2 by 5/16.

## SUBTRACTION

The operation of subtraction is defined as the process of taking one number from another number or taking away a number of things from a group of similar things. The number which is subtracted is called the "subtrahend" and the number from which it is taken is called the "minuend". The resulting number or quantity of things is called the "remainder" or "difference". The sign (—), called "minus" written between two numbers indicated subtraction.

Illustration of subtraction:

Subtract 83 from 129.

Solution:

129 --- minuend
83 --- subtrahend
46 --- difference or remainder

Problems in subtraction:

1. From 162 take 149.
2. Subtract 1729 from 2804.
3. From one thousand two hundred, subtract three hundred and forty-eight. From the remainder take five hundred and two.
4. Subtract 7/11 from 2/3.
5. 3 3/4 — 1 5/8.
6. 9 3/5 — 6 7/10.
7. Subtract 100.46 from 4,567.34.
8. Subtract 8.875 from 10.375.
9. Subtract 17 3/4 from 25 7/8.
10. 21 1/4 − 17 3/4
11. 12 5/8 − 9 3/4
12. 9 5/6 − 4 11/12

6. At 305 5/8 pounds per mile, what is the weight of 18 3/4 miles of copper wire?

7. Eight equal distances of 3.875 inches each are marked off, end to end on a piece of work. What is the total distance marked off?

8. Three men, A, B, and C, bought a boat for $300.00. A paid 35% of the cost, B paid 44%, and C 21%. How much money did each man pay out?

9. The diagonal of a square is very nearly 1 5/12 the length of one side. Find the diagonal when one side is 12 inches.

10. In Chicago, a bricklayer received 72½ cents an hour. How much would a man receive in a year if he worked 225 days of eight hours each?

11. The circumference of a circle is very nearly 355/113 times the diameter. What is the circumference of a circle whose diameter is 13 1/2 inches?

## DIVISION

Division is the reverse of multiplication. It is the method of finding how many times one number is contained in another number.

The number which is to be divided is called the dividend and the number which does the dividing is called the divisor. The result obtained is called the quotient. If the divisor goes an uneven number of times into the divident the part left over is called the remainder.

The symbol of division is ÷ and is called divided by.

Example of division:

Divide 18 by 7.

Solution:

Divisor --- 7 ) 18 --- Dividend

2 --- Quotient

14 ---

4 --- Remainder.

Problems on division:

1. Divide 3 5/8 by 3.
2. Divide 5 by 2.
3. Divide 3.1257 by 1.5.
4. Divide 14.56 by 4.
5. Divide 2805 by 234.
6. Divide 3.987 by 5.2.
7. Divide 192. 4/5 by 5.
8. Divide 418 by 3 1/2.
9. In the drawing of a house, 1/8" in the picture represents 1 ft. in the actual house. Find the dimensions of the rooms that measures as follows: $2\frac{1}{4}$ inches by 2 7/8 inches; $1\frac{1}{2}$ inches by 1 3/4 inches; 1 3/16 by 1 7/16 inches; 11/16 by 13/16.
10. How many bolts can be obtained from a bar of steel 7 3/8 feet in length, if each bolt requires a piece 3 15/16 inches long?
11. How many boards 5/8 in. thick can be stacked under a bench 40 inches high?
12. A spool contains 37.8 pounds of copper wire. How many coils weighing 4.725 pounds each can be made from the wire on the spool?

13. A pulley makes 4,044 revolutions per minute. How many revolutions does it make each second?

14. A board 5 feet 2 inches long is to be cut in the middle. What will be the length of each piece?

15. A shipping box is 77 inches long, 43 inches wide, and 58 inches high. Find the dimensions of the box in feet and in inches.

## TABLES OF MEASUREMENT

In common practice, certain equivalents are necessary. It is, however, not practical to memorize these. They are, therefore given in table form, such as may be found in any trade handbook.

### Long Measure

12 inches (in. or ") = 1 foot (ft. or ')

3 feet = 1 yard (yd)

$5\frac{1}{2}$ yards of $16\frac{1}{2}$ feet = 1 rod (rd)

320 rd. or 5280 feet = 1 mile (mi.)

### Land Measure

7.92 inches = 1 link.

25 links = 1 rod

4 rods = 1 chain

80 chains = 1 mile.

### Circular Measure

60 seconds (") = 1 minute (')

60 minutes (') = 1 degree (°)

90 degrees (°) = 1 right angle

360 degrees = 1 circumference

## Measure of area or square measure

144 square inches (sq. in.) = 1 sq. foot (sq. ft.)

9 square feet (sq. ft.) = 1 square yard (sq. yd.)

30¼ square yards = 1 square rod (sq. rd.)

160 square rods = 1 acre.

## Measures of Contents or Volume
### Cubic Measure

1,728 cubic inches (cu. in.) = 1 cubic foot.

27 cubic feet (cu. ft.) = 1 cubic yard (cu. yd.)

128 cubic feet = 1 cord (cd.)

### Dry Measure

2 pints (pt.) = 1 quart (qt.)

8 quarts = 1 peck (pk.)

4 pecks = 1 bushel (bu.)

### Liquid Measure

4 fills (gi.) = 1 pint (pt.)

2 pints = 1 quart (qt.)

4 quarts = 1 gallon (gal.)

31½ gallons = 1 barrel (bbl.)

### Avordupois Weight

16 drams = 1 ounce (oz)

16 ounces = 1 pound (lb.)

100 pounds = 1 hundredweight (cwt.)

2000 pounds = 1 ton (T.)

### Measure of Time

60 seconds (sec) = 1 munute (min.)

| | | |
|---|---|---|
| 60 minutes (min.) | = | 1 hour (hr.) |
| 24 hours | = | 1 day |
| 7 days | = | 1 week (wk.) |
| 52 weeks<br>12 calendar months<br>365 days | = | 1 year (yr.) |

## RULES FOR CALCULATING MEASUREMENTS

1. Circumference of a circle. To find the circumference of a circle multiply the diameter by 3.1416.

2. To find surface or areas:

   a. The area of a square or rectangle: multiply the length by the width.

   b. The area of a triangle: multiply the length of the base by one half the heigth or altitude.

   c. The area of a circle: multiply one-half the circumference by the radius or multiply the square of the radius times 3.1416.

   d. The area of a cylinder: multiply the circumference of the base by its length or height, and add the area of both bases or ends.

   e. The area of a cone or pyramid: multiply the circumference of the base by one-half the slant height and add the area of the base.

   f. Area of a sphere: multiply the square of the diameter by 3.1416.

3. To find contents or volumes:

a. Volume of a right prism: multiply the area of the base by the altitude.

b. Volume of a cylinder: multiply the area of the base by the height or length.

c. The volume of a wedge: multiply the area of the trangular base or end by the height or length.

d. The volume of a cone or pyramid: multiply the area of the base by one-third the height.

e. The volume of a sphere: multiply the cube of the diameter by 3.1416.

f. The volume of a spheroid: multiply product of the square of the radius and one half the height by 4.1888.

NUMBERS TO REMEMBER

| | | |
|---|---|---|
| 1 dozen | = | 12 units |
| 1 gross | = | 12 dozen = 144 units |
| 1 score | = | 20 units |
| 1 quire | = | 24 sheets |
| 1 ream | = | 20 quire |
| 1 mile | = | 5280 feet |
| 1 pace | = | 3 feet |
| 1 palm | = | 3 inches |
| 1 hand | = | 4 inches |
| 1 span | = | 10 7/8 inches |
| 1 gal. | = | 231 cubic inches |
| 1 cu. ft. | = | 7.481 gallons |
| Pi | = | 3.1416 |

# CHAPTER III

## WOODWORK

The following problems have been taken from the work of (a) carpenters, (b) bridge builders, (c) cabinet makers, (d) retail lumbermen, (e) body builders, (f) furniture manufacturers, and (g) mill workers; and all have been validated by tradesmen in each field. They represent the various type of problems faced by these workers.

These related problems in woodwork deal with labor costs, the measuring, and the cost of lumber as customarily sold. Wood, or lumber, is measured by the board foot and sold by the thousand board feet, or M. Certain types of lumber, such as laths, which are sold by the bundle or 100; or molding, which is sold by the foot, are not measured in board feet.

A board foot is a piece of wood containing 144 cubic inches. That is, it is a piece of board 12 inches square and one inch thick. A rule for securing the number of board feet in a plank is as follows: multiply the thickness in inches, by the width in feet, and multiply the product by the length in feet.

Sample problem:

A board used in construction work is 2 inches thick, 13 inches wide and 8 feet long. What is the size of the plank in board feet?

Solution: $2 \times 1\frac{1}{3} \times 8 = 24$ board feet (bd. ft.)

Illustrative problems in woodwork:

1. How many board feet are in a stick of lumber one inch thick, fifteen inches wide and eighteen inches long?

2. How many feet of cypress will it take to build a circular silo with a 6 foot radius and 26 feet high? The stock is $1\frac{1}{2}$ inches thick. Add 5% for the waste in cutting floring and $\frac{1}{4}$ for matching. [1]

3. At $38.50 per M. how much will it cost for the ceiling of a porch, that is 9 feet wide and 31 feet 6 inches long, and whose rise is 4 feet? Add $\frac{1}{4}$ for matching.

4. A man wishes to lay a board walk outside a city block that is 300 feet square. He uses 2 inch by 6 inch boards 12 feet long for the walk and 2 inch by 4 inch boards laid lengthwise under the walk for the supports of which there are three for the width of the walk. Each board is fastened down with six 20d spikes. (Thirty spikes in a pound, at $3\frac{1}{2}$ cents per pound.) How much will it cost to lay this sidewalk at $38.00 per M, allowing $42.35 for labor?

5. How many board feet of solid sheeting is necessary to cover a gable end roof if the spread of the rafters at the base is 28 feet and the pitch of the roof is 5/12 the span of the base of the rafters.

6. If it cost 10 cents a cubic foot to complete a house, what will a building 28 feet wide, 26 feet long, 12 feet to the eaves, and a gable end roof that rises 12 feet above the eaves cost?

7. With no allowance for waste, how many feet of lumber, board measure, will it take to make a watering trough 18 feet long, $2\frac{1}{2}$ feet wide, and 20 inches deep, outside measurements, with lumber

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1. E. A. Hardy, Type Problems For Use In Teaching Mathematics to Trades and industrial Education Students, pp. 1, 2.

1½ inches thick?

8. The average width of shingles being four inches and the shingles being laid 4 inches to the weather, how many will be needed to cover one square (100 sq. feet) of roof? How many if they are laid 4½ inches to the weather?

9. How many feet of siding are necessary for this house, suppose it to be 28' x32' x 18' high, the siding being 5" wise and laid 4" to the weather, no allowance being made by gables or doors or windows?

10. If he puts on a sloping roof, each slope being 34' x 18' how much will the shingles cost at $4.75 per 1000, allowing to 125 sq. feet 1000 shingles?

11. A man wants to build a house. He needs the following bill of lumber:

Sills: 3 pieces, 6" x 8", 16' long. 192 board feet.
4 pieces, 6" x 8", 14' long. ? board feet.
6 pieces, 6" x 8", 12' long. ? board feet.
1 piece, 2" x 4", 14' long ? board feet.
1 piece, 2" x 9", 8' long ? board feet

12. Joints:

30 pieces, 2" x 9", 16' long. ? board feet
18 pieces, 2" x 8", 12' long. ? board feet
13 pieces, 2" x 8", 6' long. ? board feet
27 pieces, 2" x 8", 16' long. ? board feet
27 pieces, 2" x 8", 12' long. ? board feet
27 pieces, 2" x 6", 16' long. ? board feet

13. Studding, etc.

| | | |
|---|---|---|
| 5 pieces, 2" x 6", 14' long. | ? | board feet |
| 100 pieces, 2" x 4", 14' long. | ? | board feet |
| 35 pieces, 2" x 4", 10' long. | ? | board feet |
| 25 pieces, 2" x 4", 18' long. | ? | board feet |
| 45 pieces, 2" x 5", 12' long. | ? | board feet |
| 50 pieces, 2" x 4", 8' long. | ? | board feet |
| 50 pieces, 2" x 4", 14' long. | ? | board feet |
| 40 pieces, 2" x 6", 18' long. | ? | board feet |
| Bridging, etc. | 175 | board feet |
| Roof sheating, etc. | 875 | board feet |

14. The total of problem 3-4 should be 7847 board feet. How much will this lumber cost at $19. per M.?

15. The man also needs 2000 ft B. M. siding @ $45. per M, 1950 ft. of flooring @ $22 per M, 125 of flooring for the porch @ $40 per M, 1500 shingles for the gables @ $4.25 (per thousand), 6200 shingles for the roof @ $6.50 per thousand. What will the material cost?

15. He also needs 28 foundation posts @ 30¢ each; water tables, cornice, corner boards, etc. $25. porch columns, $5, 16 doors at an average cost of $5.50 each, hardware, $40, chimney and plastering, $200.00; painting, $148; timwork, $15.50, the work of our carpenters for thirty days @ $3 per day. What is the total cost of these items?

16. A building is 36 ft. wide. The pitch of the roof is $\frac{1}{2}$ and the rafters project 15". How many shingles laid $4\frac{1}{2}$" to the weather are required if the ridgepole is 50' long.

17. Each rise in a certain stair is 7 3/32" high, and there are fifteen risers. What is the total rise of the stair?

18. A contractor agrees to build a barn for $250. He uses 6000 ft of lumber at $20 per thousand, 12 squares of roofing at $1.75 per square, and hardware at a cost of $15. Four men put in 60 hours each at $0.30 per hour. What is the profit of the contractor.

19. How many square feet of surface in a conican roof 15' in diameter at the base, and 8' feet high.

20. A carpenter is to build a len-to-shed with a roof 33' long. It has a 12' run and a 10' rise. Allowing 4" for trimming and 2' for overhanging and spacing them 18" between centers, what will be the cost of the material for the rafters for this shed if 2 x 4 sell at $20. per M.

21. How many board feet will it take to construct a platform 16 feet wide and 24 feet long, if the stock is 3 inches thick?

22. Two timbers 8 inches thick, 10 inches wide and 12 feet long to be used for skids, contains how many board feet?

23. What will be the cost of 10 planks for a platform each 13 feet long, 12 inches wide and 3 inches thick, at $40 per M.?

24. Find the number of board feet in four pieces 2" x 2' x 16', two pieces 18" x 10" x 16' and one piece 12" x 12" x 20'?

25. How many board feet is in 16 pieces of lumber, each being 14 feet long, 16 inches wide, and 3 inches thick, used to build a tool platform? Compute the cost of $32 per M.?

26. A bridge is 6 rods long and 18 feet wide. What is the cost of flooring this bridge with 3 inch plank at $22.50 per M.?

27. The floor of a bridge is 22 ft. wide. The length of the floor is 720 feet. It is to be floored with 12 x 6 planks. What will the lumber for the floor cost at $50 per M.?

28. Ten spikes are used in each board. Each spike weights 1/8 pounds. At 2 cents per pound, what will the nails cost?

29. A wooden water derrick is to be 36 feet high. It is to be built on a square base. How many pieces of 4 x 4 material 12 feet long will be required for the four corners.

30. On the above derrick, the uprights lean towards the center twelve inches in every twelve feet. What length timbers will it take to make the sills for the water table?

31. How many feet of 2 x 6 material will it take to make the girth around the derrick every six feet?

32. In each rectangular opening above the first girth a sway brace of 4" x 4" is placed. How long will each of these timbers be? How many board feet do these timbers contain?

33. The derrick is to be floored with 3" x 12" planks and 3" x 10" joints spaced on 16" centers. Find the number of board feet in this floor.

34. Wind braces are to be placed on top of the botton girth to extend to the botton side of the top girth or water table sills. They are 4" x 4" yellow pine. Find the number of board feet in material in these wind braces.

35. What is the cost of the derrick if it is to be built of yellow pine at a cost of 5 cents per foot.

36. At 14 cents per board foot for quartered white oak how much will the following bill of material for a form stand cost?

| | |
|---|---|
| 1 top | 1" x 18" x 18" |
| 4 legs | 2" x 2" x 24" |
| 4 rails | 1" x $2\frac{1}{2}$" x 14" |
| 4 rails | 1" x $1\frac{1}{2}$ x 14" |

37. A cylinder 2 inches by 6 inches is to be covered with veneer. Find the measurements of veneer necessary to cover the cylinder.

38. The following material and labor was used in making a medicine 16" x 23" inside measurements; 6 1 x 4 jambs, 10¢; 1 sheet of tim for back, 20¢; 4 casing, 12¢, 2' apron, 5¢; 2' 2" head casing, 7¢; 3'head mould 6¢; 1 door, 30¢; 1 beveled plate glass morror, $1.10; hinges and catch 24¢; labor 4 hours at 40¢ per hour. What was the cost of the case?

39. A kitchen cabinet is to be built. It is to contain panels as follows: 4 pc. 1/4" x 10"; 4 pc 1/4" x 10 1/4" x 10"; 5 pc 1/4" x 7" x 18"; 2 pc 1/2" x 7" x 9"; 1 pc 1/4" x 16" x 19"; and 1 pc 1/4" x 6" x 10". How much will this stock cost at .05 per foot?

40. There are 20 stiles of the following sizes used in the construction: 4 pc. 3/4" x 2 1/2" x 40"; 4 pc. 3/4" x 2 1/2" x 31"; 4 pc. 3/4" x 2" x 10 1/4"; 4 pc. 3/4" x 2" x 23"; 4 pc. 3/4" x 2" x 19 1/2". How many feet of white pine are in these stiles?

41. A table has under the single leg on each end a base glued up of 3/4" material. It is to be 4 x 6 x 24". There are twenty-two tables to be built. How much material in the bases of these tables and what is its cost at 15¢ per board foot?

42. The top of a table is to be built of 2" material 3" wide. It is to be 24" in width by 42" in length. It is to be tongued and grooved and glued. The waste in such a process is 20%. What will the cost of fifteen of these tops of the material if it costs $28 per M?

43. There are 1023 feet of hand rail to be made of oak. This hand rail must be 2 1/2" horizontal measurement by 3 1/2" vertical measurement moulded to a particular form. 1 1/2" material is to be used. At

$32 per M what is the cost of these rails?

44. A contractor ordered the following bill of lumber to complete the finish of a small dwelling:

| | | |
|---|---|---|
| 9 | 1 x 5 - 14' | S4S Red gum |
| 10 | 1 x 4 - 14' | S4S Red gum |
| 3 | 1 x 4 - 12' | S4S Red gum |
| 2 | 1 x 4 - 8' | S4S Red gum |
| 1 | 1 x 4 - 10' | S4S Red gum |
| 1 | 1 x 12 - 6' | S4S Red gum |
| 1 | 1 x 10 - 20' | S4S Red gum |

At 22 cents per foot for Red Gum up to 10" in width and 28 cents for Red Gum of wider widths, how much will the dealer charge for this bill?

45. A lumber dealer filled the following bill of lumber for a builder to use in finishing the back rooms of a dwelling.

| | |
|---|---|
| 20 linear feet | #6267 window stool |
| 90 linear feet | #8422 base shoe |
| 9 pieces | #8378 1/2 - 14' back band |
| 2 pieces | #8378 1/2 - 12' back band |
| 2 pieces | #8378 1/2 - 10' back band |
| 70 linear feet | #8084 door stop. |

Window stool sells at 5¢; base shoe at 1 1/2¢; back band at 4¢; and door stop at 2¢. Find the selling price.

46. A bill contains the following items.

2 - 1 x 1 5/8" - 14' C white pine S4S @ .02

20 - 1 x 1 5/8" - 10' C white pine S4S @ .02

5 - 1 5/8 x 1 5/8 - 10' #8902 White pine @ .01 3/4

3 - 1 5/8 x 1 5/8 - 10' #8905 White pine @ .02 1/2

What did the dealer charge for the bill?

47. There is 110 feet of Presdwood and 40 linear feet of 1" x 2" ash used in the baggage racks of a bus. The Presdwood can be bought for 4¢ per square foot and the ash for 22 cents per board foot. What will this material cost?

48. A body builder is paid $1.10 per hour for his work and estimates that it will take one hundred regular eight hour days to complete the job. He is offered a bonus of fifteen cents an hour if he completes it in less than the estimated time. He completed the job in ninety-four and one-fourth days. What was the size of his pay check, and did he gain or lose, and how much?

49. The cost of the woodwork including labor on a body is $1100. The bus costs $6200. What percent of the cost of the bus is the cost of the labor and materials for the woodwork?

50. A firm takes a contract for 40 typewriter tables to be built of oak with drawer sides of gum and veneer bottoms. Following is the lumber bill for one table.

| | |
|---|---|
| 1 top | 1 x 22" - 36" |
| 6 legs | 1 1/2 x 1 1/2" - 25" |
| 3 end rails, top | 7/8 x 2" - 17" |
| 3 end rails, bottom | 7/8" x 1 5/8" - 17" |
| 1 cross rail | 7/8" x 2" - 21 3/4" |
| 2 long slide rails | 7/8" x 2" - 18 3/4" |
| 2 short slide rails | 7/8" x 1 5/8" - 10 3/4" |
| 3 drawer fronts | 7/8" x 4 7/8" - 10 3/4" |
| 3 front rails- drawer slides | 1 x 1" - 10 3/4" |
| 3 handles | 1 x 2" - 6" |

Drawers - red gum.

| | |
|---|---|
| 6 drawer slides | 1/2" x 4 7/8" - 15 1/2" |
| 3 drawer backs | 1/2" x 4 3/8" - 10 1/4" |
| 6 rails - drawer slides | 1" x 2" - 10 1/2" |
| 3 rails - back drawer slides | 1" x 2" - 10 1/2" |

Veneer - 1/4"

| | |
|---|---|
| 2 sides | 15 7/8" x 17 1/2" |
| 1 back | 15 7/8" x 11 1/4" |
| 3 drawer bottoms | 17 1/2" x 11 1/4" |

Find the cost of these tables. The Oak lumber cost 11 1/4¢ per foot. The gum lumber costs 10 1/2¢ per foot, and the veneer lumber 14¢ per foot. There are 20 screws in each table at 1/2¢ each, the glue and sandpaper costs 15¢ for each table, and the finish costs 5¢ per board foot.

51. A manufacturer builds maple bookcases for a dealer whose order amounts to 75 units. Maple is bought for 10¢ per bd. ft., 1/4 inch veneer at 9¢ per sq.ft., and molding at 4¢ per linear foot. He figures 5¢ on each unit for glue and 5¢ for sandpaper. He estimates the finish at 6¢ per board foot, the maintenance at 1¢ per board foot and the overhead expense at 1¢ per board foot on the maple alone. He estimates the labor as equal to all other expenses. Following is the material bill for one book case:

| | |
|---|---|
| 2 sides | 1" x 10" - 34" |
| 3 shelves | 1" x 10" - 14" |
| 1 shelf | 1" x 8" - 14" |
| 1 top back | 1" x 3" - 14" |
| 1 bottom base (Add 1/4 for waste) | 1" x 6" - 14" |
| 3 ft. molding veneer | 1/2" x 15" - 25" |

52. There were 415 beds built for a dormitory on the campus of Oklahoma A. & M. College. Following is a material bill for one bed:

| | |
|---|---|
| 2 head posts | 2 1/2" x 2 1/2" - 29 1/2" |
| 2 foot posts | 2 1/2" x 2 1/2" - 21 3/8" |
| 1 Head Board | 1" x 16" - 37 1/8" |
| 1 Head piece | 1" x 6" - 37 1/8" |
| 1 Foot Board | 1" x 6" - 37 1/8" |
| 2 Side rails | 1" x 6" - 76" |

It was found that finish took $1.25 per unit, glue and sandpaper together 25¢ per unit, replacements one cent per board foot, and office overhead one cent per board foot. The labor cost was 30¢ per hour for 13 1/2 hours on each unit. What would it cost to build these beds?

53. A drawer case is to be built as per sketch, 3-8 x 3-6 x 1-4 deep, exposed parts Yellow Pine, balance Cypress, set up. The Case sets between plaster walls, no back nor hardware. Figure extensions and total actual cost on the following bill:

| | | | |
|---|---|---|---|
| 25 net bd. ft. | 1 1/4" | Clr Y P | @ 46.80 |
| 1/2 " " " | 1" | " " " | @ 41.25 |
| 4 " " " | 1 1/4" | 1 Shop Cyp | @ 46.80 |
| 38 " " " | 1" | " " " | @ 36.80 |

Machine costs:

| | | |
|---|---|---|
| Labor | 2.4 hours | @ .25 |
| Burden | 2.4 hours | @ .35 |

Bench costs:

| | | |
|---|---|---|
| Labor | 14.8 hours | @ .30 |
| Burden | 14.8 hours | @ .20 |

Figure the total factory cost and add 20% to this for commercial burden.

54. A stack of lumber 7' 5" wide and 12' long is composed of sixty layers of one inch boards placed edge to edge. How many board feet does the stack contain? (Consider the boards edge to edge).

55. A rough plank ten inches wide at one end and seven inches wide at the other is eight feet long and 1 5/8 " thick. How many board feet does it contain?

56. A drawing board 2' 2" wide and 2' 11" long by 1 1/4" thick is made from white pine. What will it cost at $36 per M?

57. How many board feet of flooring 4" wide are required for a circular tower floor one inch thick, the radius eight and one-half feet within the walls, add 25% for squaring and tongue and grooving waste.

58. How many board feet are required for outside wills and plates of a building twenty feet wide and forty feet long? The timbers are 2" x 8" x 13' for sills, and 2" x 6" x 18' for plates. One foot is deducted from the length of each timber for splicing.

59. The tops of school desks are often made in three pieces. Suppose that one piece is 5 3/8" wide and another 4 1/4" wide. How wide will the third piece have to be cut to make the top eighteen inches wide?

60. A billboard is to be 9' high and 15' long. It is to be built of boards 8" wide, 9' long, and 1" thick. How many boards will be required? At $30 per M, how much will the lumber used in the billboard cost? (Use commercial lengths and lumber.)

61. How much picture molding will be needed for a room which is 22' 8" long and 17' 8" wide? At 3 cents per linear foot, what will the molding cost?

62. A dining room is 18' 10" long and 16' 8" wide. If 3' 8" are

deducted for doors and windows, how many linear feet of molding will be needed for a plate rail extending completely around the room?

63. A contractor in building a home bought:

3000 ft. #2 boxing at $45 per M.

4000 ft. Lap siding B grade at $65 per M.

1800 ft. Oak floor No. 1 short oak at $70 per M.

900 ft. inside finishing at $80 per M.

200 ft. 2" x 4" joists at $45 per M.

What is the total number of board feet and the total cost?

64. How many board feet of lumber will be used in flooring a bridge 30 feet long with planks 3" by 12" x 30'. The boards are laid crosswise?

65. The sills across the bottom of a bus body are laid in 3" x 4" channel iron. If the body is laid on five sills, how many board feet of ash will be required for these sills?

66. How many square feet of 1/2" fir plywood will it take to floor a body of a bus eighty-two inches wide and eighteen feet long on the inside?

67. What will be the cost of the floor in problem 66 if 3/4" plywood sells for 14 cents per square foot.

68. A man builds a sidewalk 6' wide and 150' long. The planks are 1 1/2" x 8". Three sleepers 4" x 4" longthwise are put in for nailing. How many board feet of lumber are used?

69. An order for 30 saw horses to be used for drafting room purpose calls for 10 feet of pine 7/8" x 4", and 4' of pine 1 1/2" x 3" per saw horse. How much material is required for the job. What is the cost

of this material?

70. To build an office filing case required 6 oak boards 3/8" x 8" x 4'; 4 oak boards 3/8" x 6" x 3'; and 16 ft. of 1/4" whitewood, 8" wide. If oak costs costs $200 per thousand and whitewood $50 per thousand, what is the cost of this material?

71. A class in furniture making makes 45 inkstands out of ash. Each tray is constructed of two pieces, the base and top. The finished base is 15/16" thick, 4 5/8" wide, and 9 1/4" long. The top when finished is 7/16" thick, 4 3/8 " wide and 5/8" long. Allowing 1 inch on length and 1/4" on width of each piece for rough stock, how much will the lumber for these inkstands cost at $75 per M for 7/8" stock and $60 per M for 3/8" stock?

72. Find the cost of material for 60 tool racks, if each rack requires the following:

1 piece 2" x 2" x 18" of whitewood ($75 per M)

1 piece 5/8" x 3 3/4" x 18" of whitewood ($65 per M)

3 f. h. screws at 12¢ per gross.

73. The body posts of a bus are made of ash 1 1/2" x 3" x 6' 9". They are placed every thirty-one inches. On an eighteen foot body, how much material will it take to cut the posts for the sides if they are cut from 2" x 8"s. NOTE: The posts are curved but two posts are secured from one seven foot piece.

74. The skirting around the bottom of a body is made of 1" x 15" cypress. On an eighteen foot by eighty-six inch body, how many bd. ft. of this material will be used?

75. Cypress costs four cents per board foot. What will it cost for the material in the skirt of Problem 74.

# CHAPTER IV

## ELECTRICITY

The following problems have been taken from the electricians' trades, and have been validated by tradesmen in each field of electricity. They represent the various types of problems faced by these workers.

The unit of measure of quantity of electricity is the kilowatt hour. This unit is based on the watt, which is the unit of electrical power or quantity. One kilowatt is one thousand watts; when one kilowatt of electricity flows constantly for one hour, one kilowatt-hour (K.W.H.) of electricity has been consumed. If the amperage and voltage of, for instance, an electric toaster is known, the wattage or power required to operate it is given by the formula "Watts = Volts x Amperes".

Problems are given here in the related mathematics of the fundamentals of electricity. Since the uses of electricity in industry are many and varied, including radio, telephone, home lighting and power, and automobiles, an attempt is made to provide learning and practise in solving several typical industrial problems in electricity. Definitions of other common electrical terms in good usage may be found in any standard trade handbook, so they will not be given here. General formulae for these problems will be found in the books listed in the bibliography.

### PROBLEMS

1. Suppose that on January 1, 1936, an electric meter read 5,645 KWH, and on February 1, 1936, the reading was 5,973 KWH. What should the amount of the bill have been at the rate of 10¢ per KWH?

2. At 10% discount for cash payment before the 12th of the month

find the amount saved in the above problem if the payment is made on time.

3. On February 1, 1937, an electric meter read 1,685 KWH and on March 21, 1937, the reading was 1,816. The electric light company had the following rates:

| | | |
|---|---|---|
| First 30 KWH | --- | $.09 per KWH |
| Next 30 KWH | --- | .08 per KWH |
| Next 40 KWH | --- | .07 per KWH |
| Above 100 KWH | --- | .04 per KWH |

What is the amount of the bill?

4. Suppose that on December 1, 1937, an electric meter read 7-6-9-3 and on January 1, 1938, the reading was 7-6-9-8. Find the amount of the bill at these rates:

| | | |
|---|---|---|
| First 100 KWH | --- | 12¢ per KWH |
| Second 200 KWH | --- | 7¢ per KWH |
| Above 200 KWH | --- | 5¢ per KWH |

5. On January 2, 1937, an electric meter read 5-6-5-4, and on February 2, 1927 the reading was 5-9-7-8. What should the bill have been at 10¢ per Kilowatt-hour?

6. When an electric meter was installed on January 20, 1936, it read 1947 KWH. The following are the monthly readings taken from the meter. Find the electric light bill for each month at the prevailing rates in your town:

| | | | |
|---|---|---|---|
| | February 20 | ---- | 1863 KWH |
| 7. | March 20 | ---- | 1895 KWH |
| 8. | May 20 | ---- | 1940 KWH |

9. June 20 ---- 2236 KWH

10. July 20 ---- 2552 KWH

11. What does it cost to use a 3 ampere, 110 volt electric iron for three hours in your town?

12. What would a 220 volt motor drawing 20 amperes cost to run for 54 hours at 9¢ per KWH?

13. What is the cost of operating a 5 ampere, 110 volt toaster in your town?

14. A generator supplies 20 100-watt lamps and 16 40-watt lamps. What is the power load?

15. What is the cost of operation of four sixty-watt electric lamps for three hours in your city?

16. What will it cost to burn a 40-watt hall lamp day and night for 30 days in your home town?

17. An electric iron uses 550 watts per hour. Find the cost per week at 10¢ per KWH when the iron is used 15 hours and 30 minutes per week.

18. An electric fan pulls 60 watts per hour. Find the cost of operation for 7 days and 10 hours at 10¢ per KWH.

19. A vacuum cleaner using 225 watts per hour will cost how much to run per hour, when electricity costs 8½¢ per KWH?

20. An arc light consumes 1 watt hourly per candle power. If it is of 120 candle power and runs 300 hours, find the cost of the needed electricity at 8¢ per KWH.

21. Bring electric light bills from home and check the amount, rate, and consumption of the bills.

22 Read your home meter and figure the cost of electricity for one week.

23. An electric drill uses 800 watts per hour. Find the cost of 50 hours operation at 9½¢ per KWH.

24. An electric doorbell is operated by two cells in series. Each cell has an EMF of 1.5 volts and on closed circuit, 0.8 amperes are drawn from both cells. Find the wattage of the circuit as given.

25. (746 Watts = 1 H. P.)

An electric motor does work at the rate of 40 KW. What is its equivalent in horsepower?

26. A washing machine is operated by a 1/4 H. P. motor of 60% efficiency. If the machine is used for 4 hours per week, what will be the yearly cost when electrical energy sells at 5¢ per KWH?

Ohm's law: E = IR, where E = voltage, I = current in amps, and R = resistance in ohms. Evaluate the formula to find the missing factors.

| | E | I | R |
|---|---|---|---|
| 27. | | .55 | 11 |
| 28. | | .75 | 9 |
| 29. | 110 | | 220 |
| 30. | 110 | .75 | |
| 31. | 220 | | 450 |
| 32. | 6 | 1.50 | |

33. If I = E/R, find I when E is 110 volts and R is 9 ohms.

34. If R = E/I, find R when E is 110 volts and I of 0.5 amps.

35. How much current will flow through the windings of an electromaguet of 140 ohms resistance, when placed across a 110 volt circuit?

36. What is the resistance of an incadescent lamp on a 110 volt circuit, if the current is 1.5 amps?

37. A generator supplies 220 lamps rated at 110 volts each using 200 watts. What is the power load?

38. What current will flow through a toaster using 550 watts at 110 volts?

39. Write the formula for determining the ampere-current requirement of electric equipment.

40. Write the formula for determining the ampere-current if the power and amperage are known.

41. What H.P. will be generated in producing 12 amperes at 500 volts?

42. Allowing a 1/5 loss in efficiency, what H. P. motor will be required to drive a converter that delivers 9 amperes at 220 volts?

43. How many watt-60 lamps at 110 volts may be supplied by a generator driven by a 10 H. P. gasoline engine, counting on a 95% efficiency?

44. What will be the cost at 4 cents per KWH to run a 4400 watt heater for 6 hours?

45. How much work is done when a 40 watt lamp is lighted for 4 hours?

46. The power used in doing a piece of work is 100 kilowatts and the time taken is 3 hours. How much work is done?

47. The work done by a heater is equal to 50 KWH and the time is 200 minutes. What is the power?

48. The power used by an arc lamp is 500 watts, and the work done is 2500 KWH. Find the time.

49. The candle power of a certain lamp on a 110 volt circuit which draws 0.25 amps, is 12 candle power. How many watts per candle power are used?

50. A generator is producing 30,000 watts at 220 volts. What is the current flowing?

51. It is desired to construct an electric power line having the following general plans and description:

Construction

1. Length of line: 9.7 actual miles.
2. Poles to be set 100 feet apart.
3. Poles to be 30 ft. long, buried 3 ft. in ground.
4. Number of lines: 3.
5. Brackets to be 2 side and 1 top, fastened with 2-1/2x8" bolts.
6. Entire length of line to be straight.
7. Lines to be No. 4 bare copper wire.
8. Insulators to be one piece porcelain, 5000 V. Capacity.
9. Poles to be 30 ft. creosoted Northern Cedar, 6" tip dia.
10. Two percent of length of line to be allowed for sag.
11. Lines to be fastened to insulator with 14" each of line material.

Labor

1. Poles to be equipped and set by a pole crew of 3 men and a sub-foreman.
2. Wires to be strung and installed by line crew of 3 men and a sub-foreman, who works the same as the men.
3. One foreman who does no manual labor is counted as supervisor on the job.
4. Poles to be delivered at place of use by contract.

Time Estimates

1. Digging hole for pole, 48 minutes.
2. Equipping pole, 20 minutes.
3. Setting pole, 24 minutes.
4. Stringing and installing line, 1 3/4 hrs. per mile per line.

Current Prices

1. Pole crew, 40¢ per hour.
2. Lineman, 80¢ per hour.
3. Sub-foreman, 40% more than men in crew

51. (cont'd) Current Prices

4. Foreman, $50.00 per week.
5. Transportation, $4.00 per week.
6. Wear on tools and equipment, 2% of labor costs, excluding foreman.
7. Delivery price on poles, 20¢ per pole.
8. Material prices: current prices from catalogs.
9. Freight rates figured at 32¢ per Cwt from nearest wholesale distribution point.
10. Transportation prepaid on carload lots.

PROBLEMS

1. What will be the estimated cost of poles equipped for the insulators and set?

2. What will be the estimated cost of the 3 lines installed?

3. What will be the freight bill on all material?

4. What will be the estimated total labor bill?

5. Find the total cost of installing the line.

6. A bonus of $50. per day for less than allotted time of 36 working days and a penalty of the same amount for excess time is offered. According to your figures, what can the contractor expect?

7. How much difference would it make if a contract be let for setting the poles ready for the line crew at 70¢ each. Would it pay? Why?

8. What sort of bonus, if any, could you offer your men on this job?

9. Make out the orders for the following materials:

a. Poles.

b. All poles and hardware needed.

10. How much more would it have to cost to have used No. 4 weather-proof covered wire, instead of bare copper? Would it pay? Why?

Additional problems will be needed to illustrate applications in all these fields.

# CHAPTER V

## METAL TRADES

These problems as given here pertain to the related mathematics necessary to the metal trades such as forge shop work, foundry work, and machine shop work, as well as simpler problems in sheet metal work. They have been checked and recommended by men who work in these various trades.

The rough stock or raw material used in these trades comes in various forms. Pig iron for the foundry, for instance, may be bought in billets which are priced by weight. On the other hand, stock to be used in machine shop or forge work may come in the form of bars of various cross-sections and sizes, to be bought by weight or by length. Sheet metal, according to its thickness, is priced per unit of area. Standard specifications for any form of metal, whether billet, sheet, rod, or wire, can be found in standard trade handbooks. Standard specifications are also set up for the composition of sheet, steel, and other metals.

### PROBLEMS

1. If 28 gauge sheet iron costs $0.06 per sq. ft., find the cost of a strip 18" wide and 30" long.

2. At 38¢ per sq. ft., find the cost of a piece of copper 9" long and 7" wide.

3. Find the cost of 6 strips of aluminum 3" wide and 15" long, at 26¢ per sq. ft.

4. How many square feet of sheet iron would you need to make a stove pipe 32" long and 6" in diameter, allowing 1" for seams.

5. Find the cost of the stovepipe in #4, at 15¢ per sq. ft.

6. If 36 strips of sheet brass 1 1/4" x 7" are needed on a job, how many square feet are needed?

7. A tank to be lined with sheet copper 1/16" thick shows inside measurements of the tank to be 15" in dia. and 22" high. Give the size of the piece necessary.

8. If the belt speed on a line shaft is 2500 ft. per minute, and the belt passes over a 14" pulley and drives a 10" pulley, what is the RPM of each pulley?

9. A 10" emory wheel has a cutting speed of 4820 ft. per minute. How many RPM does it make?

10. A bandsaw runs over 2 pulleys 36" in diameter. The pulley runs at 352 RPM. What is the cutting speed of the saw?

11. It is desired to change the cutting speed of a 14" emery wheel to 4000 feet per minute. The wheel is to be driven from all 14" pulley on a countershaft making 300 RPM. What size pulley must be used on the emery wheel and what length open belt is needed, the distance between centers being 7 1/2".

12. A smokestack 36" inside diameter is made from 5/16" iron sheet stock. What would be the length of the sheet, allowing 2" for lapping?

13. A blacksmith desires to place a band around a hub on a diesel engine that is 17" in diameter. If the band is 2" square and is no allowance made for shrinking, How long a piece of iron is necessary to do the job.

14. The circular basin of a washing machine is 6' in diameter. What will it cost to copper line the bottom at $1.28 per sq. ft.?

15. The average weight of wrought iron is 480 feet per cubic feet. A bar 5" square and 4" long weighs how many pounds?

16. A driver gear has 48 teeth and its follower 21. How many revolutions will the follower make to one of the driver?

17. How much space is there between rivet holes 7/8" in diameter on a 7/16" plate?

18. What is the total tube heating surface of a boiler having 80 3" tubes, each 3/16" thick and 16' long?

19. What is the H.P. of an engine that can raise 1 1/2 ton of casing from an oil well 800 feet deep in 15 minutes?

20. A piece of work on the planer is 15" thick; it is reduced to a certain size in 5 cuts. At the first cut the tool takes off 5/32" from the thickness; then 1/8"; 3/64"; 1/32"; and the fifth cut is 1/64." What is the thickness of the finished piece?

21. A gear with several teeth stripped comes into the shop with an order for a new one. It is necessary to determine the pitch. The outside diameter is calipered and found to be 12". The teeth are counted and found to number 28. What is the pitch?

22. Find the cost of the copper in a cylindrical tank 3' high and 1 3/4' in diameter and open at the top, made of sheet copper, weighing 12 pounds per square foot at 27¢ per pound.

23. An iron casting shrinks about 1/8" per linear foot in cooling down to 70° Farhenheit. What is the shrinkage per cubic foot?

24. Find the cost at 40¢ per pound for sheet copper to line bottom and sides of a cubical vessel 7' on an edge, if the sheet copper weighs 12 oz per square foot. How many barrels will the vessel hold?

25. How long a piece of drill rod is required to make 15 drills, each 3 15/16" long, allowing 3/16" waste for each cut?

26. Britannia metal consists of 2 parts antimony, 1 part bismuth and 1 part tin. How many pounds of each are there in a casting weighing 36 pounds?

27. Bell metal is made of 4 parts copper and 1 part tin by weight. If a bell weighs 13 pounds, find the amount of copper and tin in it.

28. If two gears have a speed ratio of 3 to 1 and the larger gear has 48 teeth, how many teeth has the smaller gear?

29. If a workman drills 225 holes in 1 hr. 35 min., how long will it take him to drill 816 holes at the same rate?

30. Find the volume of a tank of the shape of a frustum of a pyramid with rectangular base 8" x 10", a top 4" x 5", and a height of 3 1/2".

31. A line shaft runs at 300 R. P. M.; a 22 in. pulley on the line shaft is belted to countershaft which rotates at 220 R. P. M.; find the size of pulley on the countershaft.

32. A tank wagon has an elliptical tank 18 feet long; the major and minor axes of the elliptical ends are 10 ft. and 4 ft. respectively. How many square feet of metal were used in making the tank?

33. In problem 32, what is the capacity in gallons of gasoline of the tank?

34. The weight of a certain quality of sheet steel is 490.2 lbs. per cubic foot. Find the weight of a plate of this steel which is 1/8" thick and has 6 1/2 square feet of surface.

35. Find the radius a tinsmith should use in laying out a circular hole for a pipe, the cross section of which is 96 square inches.

36. A tinsmith is required to make some cylinder-shaped cans to hold one gallon each and to be 6" high. What radius should be used in laying out the base?

37. A tinsmith cuts out 28 circular pieces of tin for the bottoms of cans, using a radius of 5". How many square inches of tin are there in all the pieces?

38. Find the amount of steel necessary to make a water tank, 4' 5" by 6' 4" and 38" deep.

39. How much must be paid for 1600 ft. of steel bar weighing 1.37 lb. per foot and costing $3.75 per hundred pounds?

40. If a steel tape expands 0.00016 inches for every inch of length when heated, how much will a 100 foot tape expand?

41. A round piece of work being turned in a lathe is 1.5285 inches in diameter. What is the diameter after a cut 1/64 of an inch deep is taken in the work?

42. The mixture for a casting contains 4 parts of copper, 3 parts of lead, and 5 parts of tin. How many pounds of each in a casting weighing 150 pounds?

43. The speed reduction in a set of gears is 5 to 3. If the pinion has 32 teeth, how many teeth must the driver have? If the speed of the driver is 300 R. P. M., what will be the speed of the pinion?

44. Find the number of R. P. M. for drilling a cast iron block 3/4" thick with a drill 1/4" in diameter.

45. In problem 44, find the feed necessary to drill through the block in 25 seconds.

46. A machine-steel cylinder 5' long is to be turned in a lathe

to a diameter of 7". Using a 3/32" feed and a high-speed tool, how long will it take to make the roughing cut?

47. A train of 3 gears has 48, 24, and 69 teeth. If the 48 tooth gear makes 100 revolutions per minute, how many revolutions per minute will the 69 tooth gear make?

48. A man works 2 3/4 hours on welding a casting. He uses 20 cu. ft. of oxygen at $1.56 per 100 cu. ft., 17 cu. ft. of acetylene at $3.60 per 100 cu. ft., and 5 lb. welding rod at $12.50 per cwt. He is paid $1.25 per hour. What will the job cost?

49. A flat ring casting has the following dimensions: 20" outside diameter, 12" inside diameter and 4" thick. What will the casting cost at 5¢ per pound?

50. A welded pipeline is to be constructed to the following specifications:

1. Length of line: 4,500 ft.
2. Size of pipe: 3".
3. Length of joints: 20 ft.
4. Material necessary per weld:
   a. Oxygen, 3 cu. ft.
   b. Acetylene, 2.7 cu. ft.
   c. Welding rod, 0.3 lb.
   d. Estimated time of welder, 3 minutes.
5. Pipe to be aligned and welded on top of ground by welder, then placed in ditch by others.
6. Prices:
   a. 3" black std. pipe, 18¢ per ft.
   b. Oxygen, $1.56 per 100 cu. ft.
   c. Acetylene, $3.60 per 100 cu. ft.
   d. Welding rod, $12.50 per cwt.
   e. Wear on equipment and other overhead, 30¢ per hour.
   f. Carbide, $4.90 per cwt.
   g. Welder's time, 95¢ per hour.
7. A cylinder of oxygen contains 220 cu. ft.
8. A cylinder of acetylene contains 100 cu. ft.

QUESTIONS

1. How many joints of pipe will be required?

2. If one end of the line is to be welded into another line

and the other end left open, how many welds will be required?

3. What will be the labor bill on the job?

4. How much oxygen will be used?

5. How much acetylene will be used?

6. How much welding rod will be required?

7. What will be the overhead expense of the job?

8. Make a list of the necessary materials, labor and overhead to do the job showing quantity and prices.

9. If 100 lbs. carbide will produce 500 cu. ft. of acetylene will it be cheaper to use a generator or to buy acetylene in cylinders?

10. If the pipe is welded at a temperature of 70 degrees and 100 ft. of pipe expands .0375 inch per degree of rise in temperature, how long will the line be when the temperature is 92°? How long will the line be at 15°?

# CHAPTER VI

## CONCLUSION

The value of related mathematics in industrial practise has long been recognized. Men whose daily work is with the practical problems in industry have confirmed the lackings in mathematics of the majority of those occupied in trades today. This thesis has aimed to show how this lack may be remedied. A compilation of problems has been made, which are directly valuable in the trades and industries which have been mentioned; and these problems have been validated by men who actually work in these lines of trade. It should be definitely remembered, however, that problems in related mathematics which may suit one trade may be of absolutely no value to a man working in another line of endeavor. The problems which are used in teaching related mathematics in any trade should be taken from the trade itself. That is, the teacher, instead of using abstract problems, should reword them from a practical standpoint and then go out into industry, talk with those who are conversant with the latest needs in trade mathematics, and have these men validate these new problems as being that part of mathematics actually needed.

Granting, then, that we have problems that are, in material content, actually valuable to the tradesman; we should remember that even these problems will lose their interest if taught in the old abstract manner. These problems should be taught from the laboratory standpoint defined earlier in this thesis. Students who have material taken from their chosen line of work and which is taught them in this manner cannot help but become interested in their trades. They will then not stop with the problems given in class, but will go on into independent

research in other books or lines of work. Thus, a thorough grounding in trade mathematics from a practical standpoint and by a practical method may well be the means of assisting a man to advance rapidly in his trade. It is interesting to contemplate what might be the result if, as is entirely possible, mathematics were taught from the beginning of a child's schooling by this practical method.

In the bibliography to this thesis, a list of books has been given which could be of much practical value for reference material in such practical mathematics classes as are proposed. No attempt has been made here to have the student memorize rows and rows of formulas for solving these problems. The man of industry does not attempt to remember all the mathematical formulas he uses in his daily work, but instead knows where he can find them in his trade handbook or text. His knowledge is practical rather than purely academical. He is equipped by means of practical mathematics to reason rather than to repeat mechanically. Reasoning in trade mathematics is what is required today; and as this fact is realized, mathematics will be taught more and more as here given.

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Typed By

Marvin D. Livingood