1.0 MATH FOUNDATIONS

Trades occupations require all or most of the math foundations listed below:

Math Foundations Skills		Workplace Examples
Whole numbers: **e.g.: 3, 14**	Read, write, count, round off, add, subtract, multiply and divide whole numbers.	• Order supplies • Take stock inventory • Count pars • Read serial numbers
Integers **e.g.: -5, 0, 11**	Read, write, add, subtract, multiply and divide integers.	• Read temperatures • Use survey tools • Set up computer numerical control programs • Measure air pressure
Fractions **e.g.: 1/4, 2/3, 3** $\frac{1}{2}$	Read, write, round off, add, subtract, multiply or divide fractions. Multiply or divide by a fraction.	• Take and record imperial measurements • Determine tool or material sizes • Calculate quantities
Decimals **e.g.: 8.50, 0.00375**	Read, write, round off, add or subtract, multiply or divide decimals. Multiply or divide by a decimal.	• Handle money • Take and record metric measurements • Measure tolerances • Select tool sizes
Percentages **e.g.: 10%, 40%**	Read and write percentages. Calculate the percentage one number is of another. Calculate a percetage of a number.	• Calculate tax • Read and write tolerances. • Adjust machine loads • Describe in terms of a proportion of maximum capacity or an amount of progress towards completion
Equivalent numbers **e.g.:1/2 = 0.5 = 50%**	Convert between fractions, decimals and percentages.	• Convert decimal readings on gauges to percent of output • Convert decimals to fractions to select the correct part or size of tool • Convert quantities of ingredients to decimals to calculate cost
Other number **e.g.:** $\sqrt{36}$, 9^2 **2.2 x** 10^3, π	Use square roots, powers, scientific notation and significant digits.	• Calculate power and current in three-phase motors • Use square roots to calculate dimensions for a staircase • Use powers to express the volume of tanks
Equations and formulas	Solve for problems using equations with one unknown quantity. Use formulas by inserting quantities.	• Determine where to place holes • Calculate the correct angles for rigging loads • Set prices • Use Ohm's law to check motor voltage.

Rates, ratios and proportions	Use a rate comparing two quantities with different units. Use a ratio comparing two quantities with the same units. Use a proportion comparing two ratios or rates.	• Adjust tire pressure • Mix gasoline additives • Adjust ingredients in a recipe to make more servings • Calculate speend and feed rates of a machine • Read a scale drawing • Calculate airflow rates
Measurement conversions	Convert between imperial and metric measurements. Convert to another unit within a measurement system.	• Convert units to select wrench sizes • Cut lengths of a wire • Mix colouring agents • Meet product specifications • Calculate airflow • Use scale drawings
Areas, perimeters and volumes	Calculate areas, perimeters and volumes.	• Calculate the area or perimeter of a work surface to be painted, sodded and caulked • Calculate the volume of gasoline additives or concrete required • Calculate the capacity of a storage tank
Geometry	Apply geometric concepts such as parallelism, perpendicularity and tangents.	• Find the centre of a room to install fixtures • Cut slopes to fabricate ramps • Use angles to lay out patterns for materials.
Trigonometry	Use trig to determine the size of an unknown side or angle of a triangle.	• Calculate angles for a circular staircase • Place holes on a part • Make bolt patterns for drilling or machine installation • Find offsets
Summary calculations	Calculate averages and rates other than percentages, proportions or ratios.	Calculate averages for: • fuel or power consumption • tool lifespan • speed and feed rates • material production • time needed to perform tasks
Statistics and probability	Use statistics and probability to draw conclusions.	• Estimate how much of something clients use • Predict sales trends • Determine the probability of equipment and parts failure • Describe the progress of fabrication and installation tasks

1.1 - OPERATIONS WITH INTEGERS

Integers are positive and negative whole numbers with no fractional parts. Addition is the process of finding the *sum* of two or more numbers.

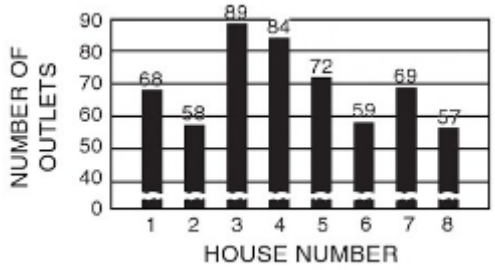
ADDING LIKE SIGNS	ADDING UNLIKE SIGNS
To add two signed numbers with like signs, add the numbers and apply the common sign. **Examples:** (-8) + (-7) = -8 - 7 = -15 6 + (+2) = +8 or simply 8 *Note that in the absence of a sign, the number is understood to be positive, i.e.:*5 means +5	1. Find the difference between two numbers excluding signs. 2. The result from Step 1 takes the sign of the integer with the greater numerical value. **Ex:** (-9) + (5) = ? **Step 1:** 9 – 5 = 4 **Step 2:** The number 4 will take a negative sign. Therefore, the answer is -4. **Alternative solution:** Treat the negative numbers the money you owe. You owe your friend $9, then pay back $5. You still have to pay $4. Therefore, the answer is -4.

Practice:

1) (-6) + (- 9) = -15	**2) (7) + (11) =** 18	**3) (5) + (-3) =** 2
4) (-2) + (7) = 5	**5) (9) + (-12) =** -3	**6) (2) + (-18) =** -16

PRACTICAL PROBLEMS

1. In wiring eight houses, you are to install outlets. The graph below shows the number of outlets to be installed in each house. Find the total number of outlets that must be roughed in.



Total = 68 + 58 + 89 + 84 + 72 + 59 + 69 + 57
= 556
∴ 556 outlets must be roughed in.

2. When taking inventory, you find that the numbers of BX connectors in five different bins are 176, 264, 375, 234 and 116. What is the total number of connectors in all bins?

Total connectors = 176 + 264 + 375 + 234 + 116
= 1165
∴ There're 1165 connectors.

3. Eight different boxes contain a number of 1/4 - inch, #8 flat-head, bright wood screws. The numbers of screws are 124, 73, 36, 92, 38, 64, 74 and 67. What is the total number of screws?

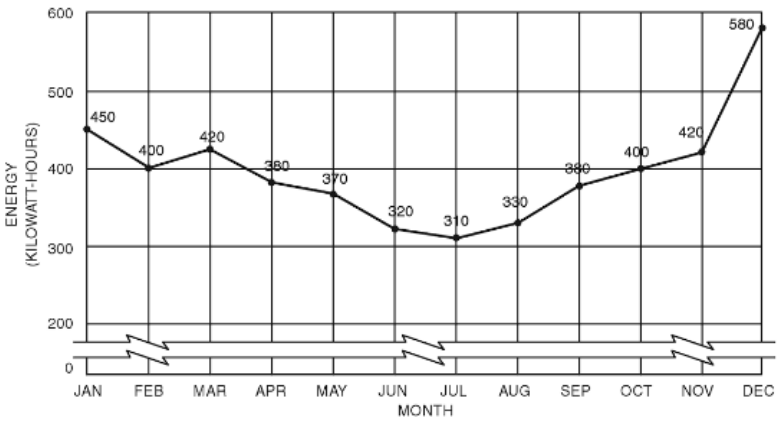
Total screws = 124 + 73 + 36 + 92 + 38 + 64 + 74 + 67
= 568
∴ There're 568 screws.

4. The materials charged to a wiring job are as follows: 100-ampere distribution panel $118; meter switch $38; conduit $64; number 2 wire $88; BX cable $73; conduit fittings $26; outlet boxes $153; switches $112; fixtures $215 and $64 for wire nuts, grounding clips, staples and pipe clams. What is the total amount charged for these materials?

Total amount = 118 + 38 + 64 + 88 + 73 + 26 + 153 + 112 + 215 + 64
= 951

∴ Total amount charged is $951.

5. The line graph shows the monthly consumption of energy in kilowatt-hours for a house during a 1-year period. Find the total amount of energy consumed during the year.



= 450 + 400 + 420 + 380 + 370 + 320 + 310 + 330 + 380 + 400 + 420 + 580

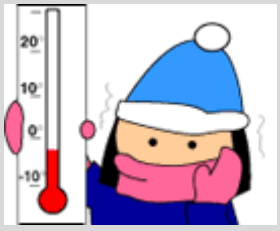
= 4760

∴ The total amount of energy consumed is 4760 kilowatt-hours.

SUBTRACTING INTEGERS

Problem: The temperature in Anchorage, Alaska was 8°F in the morning and dropped to -5°F in the evening. What is the difference between these temperatures?

RULE: To subtract an integer add its opposite



Solution:

(8) – (-5) = 8 + (+5)
= 13

The opposite of -5 is 5. Then we add 5 to 8.

The difference is 13 degrees.

PROBLEM: The highest elevation in North America is Mt. McKinley, which is 20,320 feet above sea level. The lowest elevation is Death Valley, which is 282 feet below sea level. What is the difference between these two elevations? (Note: Below sea level is a negative value.)

Solution:

= 20320 − (−282) → add the opposite
= 20320 + (282)
= 20602

∴ The difference between two elevations is 20602 feet.

PRACTICE:

a) (6) – (9) = 6 + (−9) = −3	**b) (11) – (-8) =** 11 + 8 = 19	**c) (-13) – (5) =** (-13) + (-5) = -18

PRACTICAL PROBLEMS

1. An electrician removes from stock 500 feet of BX cable on Monday, 250 feet on Tuesday and 750 feet on Wednesday. On Friday, 339 feet of BX cable are returned. How many feet of BX cable are used?

Used = Removed − Returned

Step 1 Removed = 500 + 250 + 750
= 1500

Step 2 = 1500 − 339
= 1161

∴ 1161 feet of BX cable were used.

2. An electrical contractor charges $598 for a job. The cost of materials is $263, the cost of labor is $173 and the cost of transportation is $10. Find the profit. (Profit = Revenue - Cost)

Step1 Total Cost = 263 + 173 + 10
= 446

Step2 Profit = 598 − 446
= 152

∴ The profit is $152.

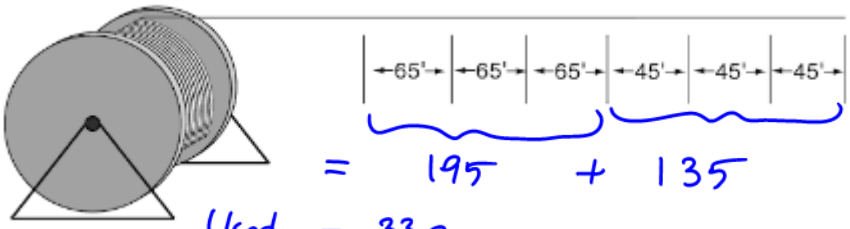
3. An inventory shows 565 outlet boxes on Jan 1. On the 10th of January, 145 boxes are taken out of stock. On the 14th of January, 35 boxes are returned to stock. How many outlet boxes are in stock after January 14?

Used = 145 − 35
= 110

Left = 565 − 110
= 455

∴ There are 455 outlet boxes in stock after Jan 14.

4. For a residential job, a reel containing 1050 feet of cable is delivered. Three 45-foot lengths and three 65-foot lengths are used. How many feet are left?



= 195 + 135

Used = 330

Left = 1050 − 330
= 720

∴ There're 720 feet of cable left.

5. A tapered pin has a small-end diameter of 101 centimeters and a large-end diameter of 189 centimeters. What is the difference between two diameters?

= 189 − 101
= 88

∴ The difference between to ends is 88 cm.

6. A purchase of 2500 feet of number 14 wire is made for a job. On November 1, 1365 feet of this wire are used. On November 3, an additional 830 feet are used. How many feet of wire are left after November 3?

Step1 Wire used = 1365 + 830
= 2195

Step2 Wire left = 2500 − 2195
= 305

∴ 305 ft left after Nov 3.

7. A customer receives an electricity bill. The bill states that 1876 kilowatt hours of energy are used. Of this total, 504 kilowatt-hours are used for lighting and the rest are for hot water. How many kilowatt-hours does the customer use for hot water?

Hot water = Total − Lighting
= 1876 − 504
= 1372

∴ The customer used 1372 kilowatt-hours for hot water.

8. A total resistance of 60 megohms is needed. On hand are three resistors with the following values: 14 megohms, 25 megohms and 11 megohms. What is the value of the additional resistor required?

On hand = 14 + 25 + 11
= 50

Needed = 60

additional = 60 − 50
= 10

∴ We need another 10megohm resistor

MULTIPLYING INTEGERS

Problem: **Alicia owes $6 to each of 4 friends. How much money does she owe?**

Solution: The problem above can be solved using integers.
Owing $6 can be represented by -6. Thus the problem becomes:
(-6) (+4)
The parentheses indicate that these integers are being multiplied. In order to solve this problem, we need to know the rules for multiplication/division of integers.

Rule 1: The product of a positive integer and a negative integer is a negative integer.
Rule 2: The product of two negative integers or two positive integers is a positive integer.

We can now use Rule 1 to solve the problem above arithmetically: (-6) (+4) = -24. So Alicia owes $24.

PRACTICE

a) (8)(4) = 32	**b) (11)(-2) =** -22	**c) (-14)(3) =** -42

PRACTICAL PROBLEMS

16 21 11

1. A panel board requires sixteen 1/2 - inch holes, twenty-one 1/4 - inch holes, and eleven 5/16 - inch holes. Each hole requires a bolt with three washers and two nuts.

a. Find the total number of washers needed for the 1/2 - inch holes.

$16 \times 3 = 48$

b. Find the total number of washers needed for the 1/4 - inch holes.

$21 \times 3 = 63$

c. Find the total number of washers needed for the 5/16 - inch holes.

$11 \times 3 = 33$

d. Find the total number of nuts needed for the 1/2 - inch holes.

$16 \times 2 = 32$

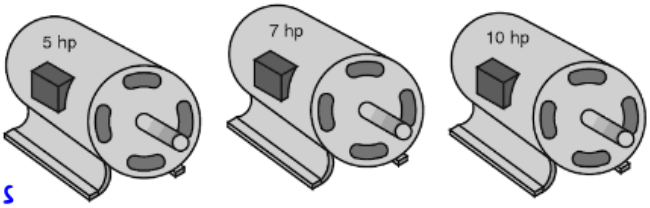
e. Find the total number of nuts needed for the 1/4 - inch holes.

$21 \times 2 = 42$

f. Find the total number of nuts needed for the 5/16 - inch holes.

$11 \times 2 = 22$

2. Find the total amount of power in watts for the three motors shown. (One horsepower equals 746 watts.)



Total in hp = 5 + 7 + 10
= 22
Total in watts = 22 × 746
= 16412

∴ 16,412 watts

3. A bearing on a large machine is tested over a period of 8 hours at a speed of 40500 revolutions per hour. How many revolutions does the shaft turn in the bearing during the test period?

$40500 \times 8 = 324000$

∴ It turns 324,000 in 8 hours.

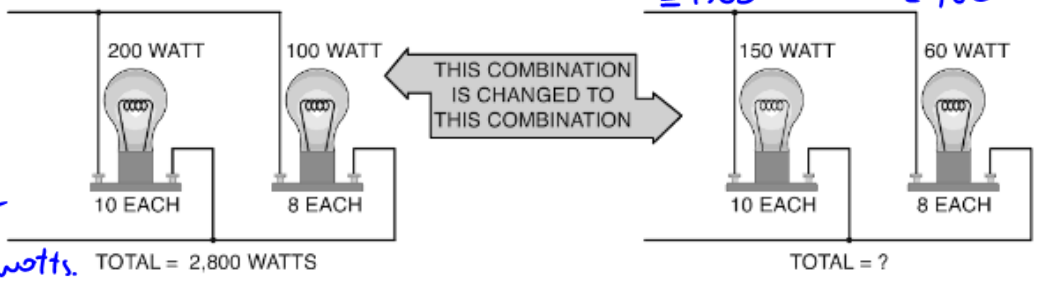
PART 1: Number Sense

4. It is found that a certain electrical circuit having a total load of 2800 watts in lamps must be reduced. Ten 200-watt lamps are replaced with ten 150-watt lamps; eight 100-watt lamps are replaced with eight 60-watt lamps. What is the total number of watts in connected lamps after the change is made?

10 x 150 = 1500 60 x 8 = 480

Total = 1500 + 480 = 1980

∴ The total number of watts is 1980 watts.

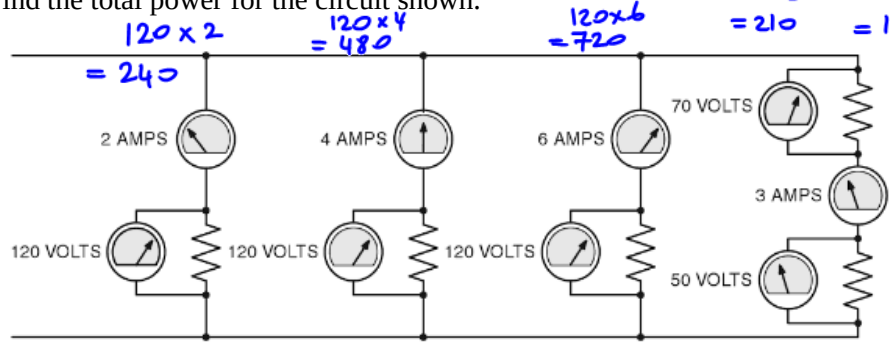


I V E

5. The product of current (amperes) and voltage (volts) equals power (watts). The total power of an electrical circuit is equal to the sum of the individual powers. Find the total power for the circuit shown.

120 x 2 = 240 120 x 4 = 480 120 x 6 = 720 70 x 3 = 210 50 x 3 = 150

Total power = 240 + 480 + 720 + 210 + 150 = 1800



∴ The total power is 1800 watts.

DIVIDING INTEGERS

Division is the process of subtracting a smaller number from a larger number a certain number of times. The larger number, the number to be divided, is called the ***dividend.*** The number used to indicate the number of times the dividend is to be divided is called the ***divisor.*** The answer is known as the ***quotient.***

Evaluate the following expressions and round your answer to the nearest hundredths (2 decimal places).

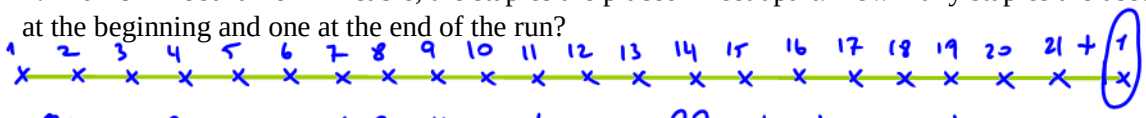
a) 1140 ÷ 17 = 67.0588 ≐ 67.06

b) 360 ÷ 23 = 15.6521 ≐ 15.65

c) 12 ÷ 36 = 0.3333 ≐ 0.33

PRACTICAL PROBLEMS

1. In a 84 - foot run of BX cable, the staples are placed 4 feet apart. How many staples are used if one staple is placed at the beginning and one at the end of the run?



84 ÷ 4 = 21 plus 1 for the end ∴ 22 staples used.

2. An electrical contractor purchases 15 fittings of one type for $45 and 6 of another type for $36.

a) Find the cost per fitting for those costing $45.

15 x 45 = $675

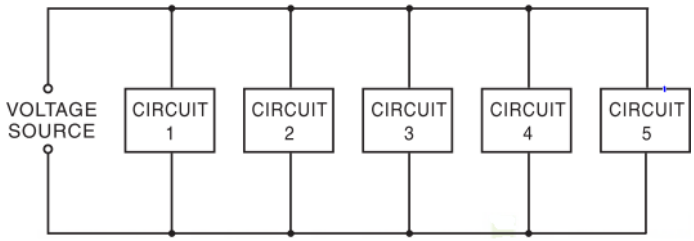
b) Find the cost per fitting for those costing $36.

6 x 36 = $216

3. A total load of 25,620 watts is distributed equally over the 5 branch circuits shown. What is the average load per circuit in watts?

$25620 \div 5 = 5124$

∴ Average load per circuit is 5124 watts.



4. How many 250 - foot rolls of BX cables are needed if a job requires a total of 5250 feet?

$5250 \div 250 = 21$

∴ You need 21 rolls.

5. A hotel with 22 rooms on each of its seven floors has a total of 770 outlets. If each room has the same number of outlets, how many are there in each room?

Total rooms = 22×7
$= 154$

$770 \div 154 = 5$

∴ There're 5 outlets on each room.

6. In a house where 35 outlets are installed, 735 feet of cable are used. What is the average number of feet of cable used per outlet?

$735 \div 35 = 21$

∴ The average number of feet of cable used per outlet is 21 feet.

7. Twelve standard packages of conduit fittings are purchased. The combined weight is 780 pounds. What is the weight per package?

$780 \div 12 = 65$

∴ The weight per package is 65 pounds.

8. Two electricians work a total of 640 hours on a job. Each works 8 hours per day, 5 days per week. How many weeks does each electrician work?

$640 \div 2 = 320$ hours
$320 \div 8 = 40$ days
$40 \div 5 = 8$ weeks

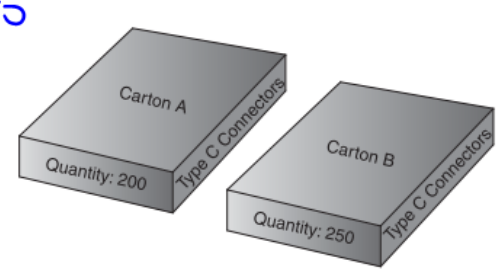
∴ Each worked 8 weeks

9. Box A and box B each contain type C connectors. Box A contains 200 connectors and costs $30. Find the cost of box B, which contains 250 connectors. The unit price is the same for both boxes.

Unit price $= \frac{30}{200}$
$= \$0.15$

Cost of Carton B $= 0.15 \times 250$
$= \$37.50$

∴ It costs $37.50.



1.2 - ORDER OF OPERATIONS WITH INTEGERS

Evaluate the following expressions:

B – Brackets
E – Exponents
D – Division
M – Multiplication *
A – Addition
S – Subtraction **
*division & multiplication in the order they appear from left to right
**addition & subtraction in the order they appear from left to right.

Ex1: 4 x (8 + 7) = $4 \times (15)$
$= 60$

Ex2: (10 x 2) ÷ 5 = $(20) \div 5$
$= 4$

Ex3: (18 + 10) - (6 + 12) = $(28) - (18)$
$= 10$

Ex4: (6 – 3) ÷ (10 – 9) + (24 – 4) ÷ (5)
$= (3) \div (1) + (20) \div 5$
$= 3 + 4$
$= 7$

PRACTICAL PROBLEMS

1. An electrical contractor employs 16 people. Five people earn $15 per hour, four people earn $17 per hour and the remaining people earn $16 per hour. What is the total hourly wage earned by all 16 people?

5×15 4×17 7×16

$= 5 \times 15 + 4 \times 17 + 7 \times 16$
$= 255$ in total

∴ The hourly wage in total is $255.

2. A wiring job requires 5127 feet of cable. If the cable comes in 250-foot coils, how many coils of cable are required?

$5127 \div 250 = 20.5$ ∴ You need 21 coils.

3. Twenty standard cartons of octal boxes weigh a total of 1100 pounds. Find the weight per carton.

$1100 \div 20 = 55$ ∴ Weight per carton is 55 pounds.

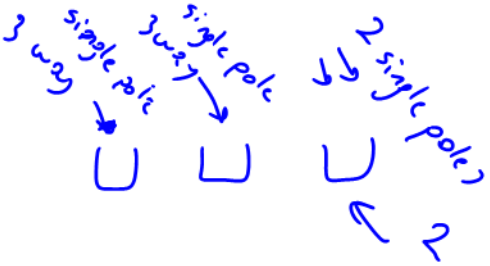
4. An electrician takes a job wiring 25 identical apartments. Each apartment contains 16 outlets that fit in a single-gang box and 6 single-pole switches that fit in a single-gang box. In addition to the single-gang switches, there are three 2-gang switch boxes. Two of the 2-gang switch boxes contain a single-pole switch and 3-way switch. The third 2-gang box contains two single-pole switches.

a. How many single-gang boxes are required to wire the 25 apartments?

16 outlets
$= 6 \times 25 + 16 \times 25$
$= 550$
∴ 550 single-gang boxes are required

b. How many 2-gang boxes are required to wire the 25 apartments?

$= 3 \times 25$
$= 75$
∴ 75 2-gang boxes are required



c. How many outlets are required to wire these apartments?

$= 16 \times 25$
$= 400$
∴ There're 400 outlets

c. How many single-pole switches are required to wire these 25 apartments?

$= 25 \times 6 + 25 \times 2 + 25 \times 2$
$= 250$
∴ There're 250 sps.

d. How many 3-way switches are required to wire these 25 apartments?

$= 25 \times 2$
$= 50$
∴ There're 50 3 way switches.

6. What is the power consumed in watts by a 12 AWG conductor that is 200 ft long, and has a total resistance of 0.40 ohms, if the current (I) in the circuit conductors is 16A? [102.40W]
Formula: Power = $I^2 R$

$= (16)^2 \times 0.40$ ∴ The power consumed is 102.40 watts.
$= 102.40$

7. What is the area in square inches (sq in.) of a trade size 1 raceway with an inside diameter of 1.049 in.?
Formula: Area = πr^2 [0.86 sq in.]

Step1 : Calculate "radius". Step2 : Area = $\pi(0.5245)^2$ ∴ It's approx.
$r = 1.049 \div 2$ $\div 0.86$ 0.86 sq in.
$= 0.5245$

8. The phase voltage of a 120/208V system is equal to 208V/√3 which is 120.09.

9. In wiring eight houses, the electricians install 68, 87, 57, 74, 49, 101, 99 and 56 outlets. Find the total number of outlets that must be roughed in.

$= 8 \times (68 + 87 + 57 + 74 + 49 + 101 + 99 + 56)$
$= 8 \times 591$ ∴ The total number of outlets is 4728.
$= 4728$

10. A purchase of 2500 feet of number 14 double-braided, rubber-covered wire is made for a job. On Nov 1, 978 feet of this wire are used, and on Nov 3, 1023 feet are used. How many feet of wire are left?

$= 2500 - (978 + 1023)$ ∴ 499 feet of wire are left.
$= 2500 - 2001$
$= 499$

11. Receptacle boxes are placed 12 feet apart. Holes are drilled in the wall studs 1 foot above the boxes to permit Romex wire to be run between them. Each receptacle box is 3 inches deep, and 6 inches of wire extends beyond the edge of a box. How many receptacle boxes can be wired with on box of Romex wire? (**Note:** A box of Romex wire contains 250 feet.)

248 feet