

Electro Critical Skills Resource Suite



Entry Level Literacy and Numeracy Assessment for the Electrotechnology Trades

Enrichment Resource

UNIT 7: Percentages



managing apprentice progression

An E-Oz Energy
Skills Australia project.



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PERCENTAGES

Percentage values are used extensively in the study of motors, generators and alternators. They are also applied in the study of resistors, transformers and time constraints.

For example, percentages are used to express the degree of power supply regulation, efficiency of a device, degree of slip in a motor motors and tapping of transformers.

LEARNING OUTCOME

- Can accurately calculate percentages

PERFORMANCE CRITERIA

- Expresses fractions and decimals as a percentage.
- Uses the calculator to accurately express one quantity as a percentage of another.
- Uses the calculator to accurately calculate the percentage of a value.
- Uses the calculator to accurately calculate percentage increase and decrease.
- Uses the calculator to solve electrical problems involving percentage calculations.



PRELIMINARY EXERCISE

Multiplying and Dividing by 10's

When multiplying by multiples of ten, the decimal point is moved over the same number of places as there are zeros in the multiplier, eg.:

$3.54 \times 10 = 35.4$	(One zero implies one place).
$3.54 \times 100 = 354$	(Two zeros implies two places).
$3.54 \times 1000 = 3540$	(Three zeros implies three places).

EXERCISE 1

Calculate answers to the following without using a calculator.

- | | |
|---------------------------|-------------------------|
| a) $0.73 \times 10 =$ | b) $0.73 \times 1000 =$ |
| c) $12.60 \times 100 =$ | d) $0.0089 \times 10 =$ |
| e) $761.2 \times 100 =$ | f) $3.504 \times 100 =$ |
| g) $.6821 \times 10000 =$ | |

When dividing by multiples of ten, the decimal point moves to the left. Again, the same number of places as there are zeros in the divisor, eg.

$2.67 \div 10 = 0.267$	$398.6 \div 10 = 39.86$
$2.67 \div 100 = 0.0267$	$398.6 \div 100 = 3.986$
$2.67 \div 1000 = 0.00267$	$398.6 \div 1000 = .3986$

EXERCISE 2



Using the calculator

Calculate answers to the following using the calculator.

- | | |
|------------------------|------------------------|
| a) $0.087 \div 10 =$ | b) $56.8 \div 100 =$ |
| c) $156.7 \div 1000 =$ | d) $2.4 \div 100 =$ |
| e) $0.003 \div 10 =$ | f) $100.67 \div 100 =$ |



Use the answer sheet to check your work.

WHAT IS A PERCENTAGE?

A percentage is a special fraction. Per cent means out of one hundred or per 100.

Percentages are fractions with 100 on the bottom (the denominator).

$$\text{Hence: } 7\% = \frac{7}{100}$$

$$50\% = \frac{50}{100} = \frac{1}{2}$$

$$100 = \frac{100}{100} = 1 \text{ ('everything')}$$

EXERCISE 3

Match each of the short statements below with the most likely percentage. Draw a line to link the statement and the percentage.

Blood Alcohol Content

9.2%

Time and Half Overtime Rate

3%

Totally Fat Free

.05%

All Steel Construction

150%

Tax Rate

0%

A Wage Rise

100%

Operating on Half Load

50%

Superannuation Contribution

33%

PERCENTAGE DIAGRAMMS

EXERCISE 4

Complete the following statements:

- a) 8 per cent means $\frac{\quad}{100}$ or parts in 100 parts
- b) 4 per cent means in 100
- c) 3.9 per cent means $\frac{\quad}{100}$
- d) $5\% = \frac{\quad}{100} = \frac{\quad}{20}$ (cancelling by 5's)

EXERCISE 5

Write the following percentages as simple fractions (cancel down the answer where possible).

- a) 25% =
- b) 60% =
- c) 11% =
- d) $12\frac{1}{2}\% = \frac{25\%}{2}$
 $= \frac{25}{2} \times \frac{1}{100}$
 $= \frac{25}{2 \times 100}$
 $=$
 $=$
- e) $33\frac{1}{3}\% = \frac{\dots\%}{3}$
 $= \frac{\quad}{3 \times 100}$
- f) $7\frac{1}{4}\% =$



Use the answer sheet to check your work.

WRITING FRACTIONS AND DECIMALS AS PERCENTAGES

To express a fraction or decimal as a percentage simply multiply by 100 and put the % sign in place.

Example 1 - Decimals to Percentages

- a) 0.31 as a percentage $0.31 \times 100\% = 31\%$



Using the calculator

0 . 3 1 x 1 0 0 =

Answer 31%

b) 0.8 as a percentage $0.8 = 0.8 \times 100\% = 80\%$



Using the calculator

0 . 8 x 1 0 0 =

Answer 80%

Example 2 - Fractions to Percentages

a) Write $\frac{1}{4}$ as a percentage:

$$\begin{aligned} \frac{1}{4} &= \frac{1}{4} \times \frac{100}{1} \\ &= \frac{100}{4} \\ &= 25\% \end{aligned}$$



Using the calculator

1 ÷ 4 x 1 0 0 =

Answer 25%

b) Write $\frac{45}{50}$ as a percentage:

$$\begin{aligned} \frac{45}{50} &= \frac{45}{50} \times \frac{100}{1} \% \\ &= \frac{45}{1} \times \frac{2}{1} \% \\ &= 90\% \end{aligned}$$



Using the calculator

4 5 ÷ 5 0 x 1 0 0 =

Answer 90

or



Using the calculator

4 5 ÷ 5 0 % =

Answer 90



Note: Steps used on some calculators may differ. Refer to your calculator guide.

EXERCISE 6

Write these fractions as percentages using the calculator. (Correct to 2 decimal places where appropriate)

a) $\frac{1}{10} =$

b) $\frac{5}{8} =$

c) $\frac{7}{9} =$

d) $\frac{45}{80} =$

EXERCISE 7

Using the calculator, complete the following table of commonly used fractions and percentages and try to remember them.

FRACTION	PERCENTAGE
$\frac{1}{4}$	
$\frac{1}{2}$	
$\frac{3}{4}$	
$\frac{1}{5}$	
$\frac{2}{5}$	
$\frac{3}{5}$	
$\frac{4}{5}$	
$\frac{1}{8}$	
$\frac{3}{8}$	
$\frac{1}{3}$	
$\frac{2}{3}$	
$\frac{1}{6}$	
$\frac{1}{10}$	
$\frac{1}{20}$	



Use the answer sheet to check your work.

EXPRESSING ONE QUANTITY AS A PERCENTAGE OF ANOTHER

If we want to express the ratio of one quantity to another as a percentage then we must first record the two quantities as a fraction.

Example 3

Of 760 light fittings produced, 80 had defects. What percentage had defects?

$$\frac{80}{760} \times 100$$
$$= \frac{8000}{760}$$

= 10.53% (two decimal places)



Note: Steps used on some calculators may differ. Refer to your calculator guide.

8

0

÷

7

6

0

%

=

Answer 10.53%

EXERCISE 8

Express the following as percentages:

a) 26 out of 62

b) 13 out of 27

c) 76 out of 220

d) 3 out of 75

e) 40 is what percentage of 320?

f) 184 as a percentage of 73



Use the answer sheet to check your work.

EFFICIENCY

Efficiency of an electrical device can be calculated using the following formula:

$$\begin{aligned}\text{Efficiency} &= \frac{\text{Power Output} \times 100}{\text{Power Input}} \\ &= \frac{\text{Power Output \%}}{\text{Power Input}}\end{aligned}$$

The power output is expressed as a percentage of the power input.

This tells us how efficiently the device is using the available power. The higher the percentage, the more efficient the device.

Efficiency Formula

Efficiency
$= P_{\text{out}} / P_{\text{in}} \times 100\%$
$= P_{\text{out}} / P_{\text{in}} \%$

Example 4

If a mechanical device has a power input of 160W and a power output of 120W, find the efficiency.

$$\text{Efficiency} = \frac{120}{160} \times 100 = 75\%$$



Using the calculator

1 2 0 ÷ 1 6 0 %

Answer 75%

EXERCISE 9

Find the efficiency of the following devices given the power output and input.

- a) Amplifier
Output = 100W Input = 250W
- b) Electric Motor
Output = 3kW Input = 3.35kW
- c) Radiator
Output = 1000W Input = 1010W
- d) Solar Cell
Output = 1W Input = 5W

EXERCISE 10

List the devices in Exercise 10 in order of efficiency from most efficient to least efficient.

- 1.
- 2.
- 3.
- 4.



Use the answer sheet to check your work.

FINDING A PERCENTAGE OF A VALUE

Example 5

12% of \$250

$$= \frac{12}{100} \times \frac{250}{1}$$

$$= \$30$$



Using the calculator

-
or

Answer 30

Answer 30

EXERCISE 11

Calculate the following:

- a) 45% of 300 =
- b) 140% of 0.05 =
- c) 65% of 1200 =
- d) 0.020% of 1500kHz =

EXERCISE 12

If a company must reduce its workforce of 670 by 20%, how many workers must be retrenched?

EXERCISE 13

If you earn 5% commission on sales of \$2,000, how much commission do you earn?



Use the answer sheet to check your work.

PERCENTAGE INCREASE AND DECREASE

Quantities such as changes in amperage, increases in voltage and ranges in resistance are often expressed as percentage changes.

A cable is overloaded by 26%.

The amperage of a current in a circuit decreases by 25%.

A resistor is labelled as having a resistance of 220hms plus or minus 5%.

Example 6

A multimeter is priced at \$250 plus 20% sales tax. How much do you have to pay for the multimeter?

The increase is given as a percentage of the original, so the increase in this example is 20% of \$250:

$$\begin{aligned}\frac{20}{100} \times 250 \\&= \frac{20}{100} \times 250 \\&= 2 \times 25 \\&= \$50\end{aligned}$$



Using the calculator

Note: Steps used on some calculators may differ. Refer to your calculator guide.

2	5	0	x	2	0	%	=
---	---	---	---	---	---	---	---

 Answer \$50

∴ The new expenditure = original expenditure + increase

$$\begin{aligned}&= \$250 + \$50 \\&= \$300\end{aligned}$$

Example 7

At a switchboard the voltage is 240V. At the end of a circuit which is fed by the switchboard, the voltage has dropped by 5%.

What is the voltage at the end of the circuit?

5% of 240V

$$\begin{aligned}\frac{5}{100} \times 240 &= \frac{5}{100} \times 240 \\&= 12V\end{aligned}$$

∴ Voltage at the end of the circuit

$$\begin{aligned}&= 240V - 12V \\&= 228V\end{aligned}$$

EXERCISE 14

The power output of a broadcast station is increased by 40%. If the original power output was 1000W what is the new output?

EXERCISE 15

A resistor is marked as being 47,000 ohms $\pm 10\%$.

What is the maximum acceptable value of the resistor?

What is the minimum acceptable value of the resistor?

EXERCISE 16

A resistor is labelled as having a resistance of 22 ohms plus or minus 5%. When measured the same resistor is found to have an actual resistance of 21 ohms.

Is this value acceptable? (Show your working)



Use the answer sheet to check your work.

PERCENTAGE CHANGE

A useful way to examine the change in size of quantity is to calculate its increase or decrease as a percentage of its original size.

In some instances it is necessary to find the percentage of change of some electronic characteristic.

This can be calculated by using the following formula.

$$\% \text{ of change} = \frac{\text{change} \times 100}{\text{original value}}$$

Example 8

The voltage is increased from 100 to 125 volts.
What is the percentage of increase?

$$\begin{aligned} \% \text{ of change} &= \frac{125 - 100}{100} \times 100 \\ &= \frac{25}{100} \times 100 \\ &= 25\% \end{aligned}$$



Using the calculator

Note: Steps used on some calculators may differ. Refer to your calculator guide.

1 2 5 - 1 0 0 = Answer \$25

Then

÷ 1 0 0 % Answer 25%

Answer The voltage has increased by 25%.

Example 9

If the voltage is decreased from 125 to 100.
What is the percentage of decrease?

$$\begin{aligned}\% \text{ of change} &= \frac{125-100}{125} \times 100 \\ &= \frac{25}{125} \times 100 \\ &= 20\%\end{aligned}$$



Using the calculator

1 2 5 - 1 0 0 =

Answer 25

Then

÷ 1 2 5 % Answer 20%

Answer The voltage has decreased by 20%

EXERCISE 17

Current in a circuit decreases from 8 to 6 amperes.
What is the percentage of decrease?

EXERCISE 18

A cable is rated to carry up to 50 amps. It is however measured to be carrying 63 amps. By what percentage is the cable overloaded?

EXERCISE 19

A transformer is used to step up voltage from 240 volts to 420 volts. By what percentage has the voltage been increased?

EXERCISE 20

Voltage in a Circuit is increased from 120 to 130 volts. What is the percentage of increase?

PERCENTAGE OF ERROR

In some situations an electrician needs to know percentage of error. For example, suppose that the calculated value of a quantity is 60 volts but the measured value is 66 volts.

$$\begin{aligned}\% \text{ error} &= \frac{\text{difference}}{\text{reference value}} \times 100 \\ &= \frac{66-60}{60} \times 100 \\ &= \frac{6}{60} \times 100 \\ &= 10\%\end{aligned}$$

Answer

The percentage error in the measured voltage value is 10% (too high.)

EXERCISE 21

Resistance in a circuit should be 50,000 ohms, but the actual value is 48,000 ohms. What is the percentage of error?

EXERCISE 22

Voltage in a circuit is 120 volts, but it should be 128 Volts. What is the percentage of error?



Use the answer sheet to check your work.

PERCENTAGE RULES

1. Percentage is a method of writing hundredths as whole numbers.

Example $\frac{63}{100}$ is 63%; In reverse, 63% is $\frac{63}{100}$ or .63

a) $\frac{5}{100} = 5\% = .05$

b) $19\% = \frac{19}{100} = .19$

c) $.89 = \frac{89}{100} = 89\%$

The whole of anything is 100% or $\frac{100}{100}$ or 1

2. Decimals are changed to percent by multiplying by 100 and adding the "%" sign. This is the same as moving the decimal point two places to the right.

a) $.77 = .77 \times 100\% = 77\%$

b) $1.05 = 1.05 \times 100\% = 105\%$

c) $.002 = .002 \times 100\% = .2\%$

3. Fractions are changed to percent by first changing to a decimal then use the procedure outlined in (2).

$$\frac{7}{8} = 7 \div 8 = .875 \text{ or } 87.5\%$$

4. Percent is changed to a decimal by dividing by 100. This is the same as moving the decimal point two places to the left and dropping the "%" sign.

a) $93\% = .93$

b) $140\% = 1.40$

c) $.7\% = .007$

5. To find what percent one number is of another: Establish a fraction - the part is the numerator; the whole is the denominator. Express this fraction as a percentage.

Example

An apprentice was asked to Install 80 metres of cable on a building site. At the end of the day the apprentice had Installed 60 metres.

What percent of the cable did he Install?

$$\frac{60}{80} = 60 \div 80 = .75 = 75\%$$

6. To find what a certain percent of a number is, change the percent to a decimal and multiply.

Example

What is 20% of 600?

$$20\% \times 600 = \frac{20}{100} \times 600 = .20 \times 600 = 120$$

ANSWERS

EXERCISE 1

- a) $0.73 \times 10 = 7.3$
- b) $0.73 \times 1000 = 730$
- c) $12.60 \times 100 = 1260$
- d) $.0089 \times 10 = 0.089$
- e) $761.2 \times 100 = 76120$
- f) $3.504 \times 100 = 350.4$
- g) $.6821 \times 10000 = 6821$

EXERCISE 2

- a) $.087 + 10 = 0.0087$
- b) $56.8 + 100 = 0.568$
- c) $156.7 + 1000 = 0.1567$
- d) $2.4 + 100 = 0.024$
- e) $0.003 + 10 = 0.0003$
- f) $100.67 + 100 = 1.0067$

EXERCISE 3

Blood Alcohol Content = .05%

Time and Half Overtime Rate = 150%

Totally Fat Free = 0%

All Steel Construction = 100%

Tax Rate = 33%

A Wage Rise = 3%

Operating on Half Load = 50%

Superannuation Contribution = 9.2%

EXERCISE 4

- a) 8% means $\frac{8}{100}$ or 8 parts in 100
- b) 4% means 4 parts in 100
- c) 3.9% means $\frac{3.9}{100}$
- d) 5% means $\frac{5}{100} = \frac{1}{20}$

EXERCISE 5

$$\text{a) } 25\% = \frac{25}{100} = \frac{1}{4}$$

$$\text{b) } 60\% = \frac{60}{100} = \frac{3}{5}$$

$$\text{c) } 11\% = \frac{11}{100}$$

$$\text{d) } 12\frac{1}{2}\% = \frac{25}{200} = \frac{1}{8}$$

$$\text{e) } 33\frac{1}{3}\% = \frac{100\%}{3} = \frac{100}{3 \times 100} = \frac{100}{300} = \frac{1}{3}$$

$$\text{f) } 7\frac{1}{4}\% = \frac{29\%}{4} = \frac{29}{4 \times 100} = \frac{29}{400}$$

EXERCISE 6

$$\text{a) } \frac{1}{10} = 10\%$$

$$\text{b) } \frac{5}{8} = 62.5\%$$

$$\text{c) } \frac{7}{9} = 77.78\%$$

$$\text{d) } \frac{45}{80} = 56.25\%$$

EXERCISE 7

$$1/4 = 25\%$$

$$1/2 = 50\%$$

$$3/4 = 75\%$$

$$1/5 = 20\%$$

$$2/5 = 40\%$$

$$3/5 = 60\%$$

$$4/5 = 80\%$$

$$1/8 = 12.5\%$$

$$3/8 = 37.5\%$$

$$1/3 = 33.33\%$$

$$2/3 = 66.67\%$$

$$1/6 = 16.67\%$$

$$1/10 = 10\%$$

$$1/20 = 5\%$$

EXERCISE 8

$$\text{a) } \frac{26}{62} \times 100 = 41.94\%$$

$$\text{b) } \frac{13}{27} \times 100 = 48.15\%$$

$$\text{c) } \frac{76}{220} \times 100 = 34.55\%$$

$$\text{d) } \frac{3}{75} \times 100 = 4\%$$

$$\text{e) } \frac{40}{320} \times 100 = 12.5\%$$

$$\text{f) } \frac{184}{73} \times 100 = 252.05\%$$

EXERCISE 9

$$\text{a) Efficiency} = \frac{100 \times 100}{250} = 40\%$$

$$\text{b) } \frac{3 \times 100}{3.35} = 89.55\%$$

$$\text{c) } \frac{10000}{1010} = 99\%$$

$$\text{d) } \frac{1 \times 100}{5} = 20\%$$

EXERCISE 10

- 1) Radiator
- 2) Electric Motor
- 3) Amplifier
- 4) Solar Cell

EXERCISE 11

- a) 45% of 300 = 135
- b) 14% of 0.05 = 0.007
- c) 65% of 1200 = 780
- d) 0.02% of 1500kHz = 0.3kHz

EXERCISE 12

20% of 670 = 134 workers

EXERCISE 13

5% of \$2000 = \$100

EXERCISE 14

40% of 1000

$$= \frac{40}{100} \times \frac{1000}{1} = 400W$$

$$\begin{aligned} \text{New Output} &= 1000W \div 400W \\ &= 1400W \end{aligned}$$

EXERCISE 15

10% of 47000

$$= \frac{10}{100} \times \frac{47000}{1} = 4700$$

$$\begin{aligned} \text{Maximum acceptable value of resistor} &= 47000 \div 4700 \\ &= 51700\text{ohms} \end{aligned}$$

$$\begin{aligned} \text{Minimum acceptable value of resistor} &= 47000 - 4700 \\ &= 42300\text{ohms} \end{aligned}$$

EXERCISE 16

5% of 22

$$= \frac{5}{100} \times \frac{22}{1} = 1.1$$

Therefore the acceptable range of resistance

$$= 22 \div 1.1 \text{ to } 22 - 1.1$$

$$= 23.1 \text{ to } 20.9$$

A resistance of 21ohms lies within this range, therefore this is an acceptable value.

EXERCISE 17

% of change

$$= \frac{8-6}{8} \times 100$$

$$= \frac{2}{8} \times 100 = 25\%$$

The current has decreased by 25%

EXERCISE 18

% of change

$$= \frac{63-50}{50} \times 100$$

$$= \frac{13}{50} \times 100 = 26$$

The cable is overloaded by 26%

EXERCISE 19

% of change

$$= \frac{420-240}{240} \times 100$$

$$= \frac{180}{240} \times 100 = 75$$

The voltage has been increased by 75%

EXERCISE 20

$$\begin{aligned} &\% \text{ of change} \\ &= \frac{130 - 120}{120} \times 100 \\ &= \frac{10}{120} \times 100 = 8.33 \end{aligned}$$

The voltage has increased by 8.33%

EXERCISE 21

$$\begin{aligned} &\% \text{ error} \\ &= \frac{50000 - 48000}{50000} \times 100 \\ &= \frac{200}{50000} \times 100 \\ &= 4 \end{aligned}$$

The percentage error in the resistance is 4% too low

EXERCISE 22

$$\begin{aligned} &\% \text{ error} \\ &= \frac{128 - 120}{128} \times 100 \\ &= \frac{8}{128} \times 100 = 6.25 \end{aligned}$$

The percentage error in measured voltage is 6.25% too low