British Occupational Hygiene Society

FACULTY OF OCCUPATIONAL HYGIENE

Introductory Guide to Mathematics for Occupational Hygiene 1:

Local Exhaust Ventilation (LEV) Mathematics

August 2025

Version 1

Introductory Guide to Mathematics for Occupational Hygiene 1: Local Exhaust Ventilation (LEV) Mathematics

This is the first in a series of introductory guides to the maths that underpins occupational hygiene calculations both in daily practice and in examinations.

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Disclaimer

Feedback

We welcome feedback on this guide.
Comments should be sent to BOHS at membership@bohs.org.

Version History

Version	Release date	Comments and amendments
Version 1	August 2025	Original version

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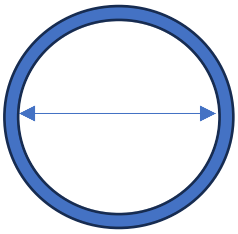
Note: The international system of units (SI units) must be used for all calculations. If any terms within a formula have been measured using different units (for example, millimetres, Celsius), then these will need to be converted into SI units.

Base Quantity	Unit	Symbol
Length	Metres	m
Mass	Kilograms	Kg
Time	Seconds	s
Temperature	Kelvin	K
Pressure	Pascal	Pa

1. Area of Shapes

To complete LEV measurements and calculations for a system, you are required to calculate the areas of the ducts and hoods. To allow accurate calculation of airflows through a system, it is important to measure within the openings e.g. internal diameter of a duct. The most common shapes for these components include circular, rectangular/square, and oval. Make sure you are confident with the following area calculations.



1.1 Area of a Circle

The area of a circle is calculated using either of the following formulae:

$$A = \pi r^2$$

Or

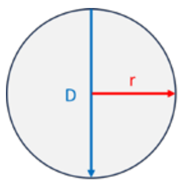
$$A = \frac{\pi D^2}{4}$$

$A = Area\ (m^2)$

$\pi = unitless\ constant\ (3.14159 \ldots)$

$r = radius\ of\ the\ circle\ (m)$

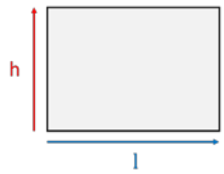
$D = Diameter\ (m)$



1.2 Area of a Rectangle/Square

The area of a rectangle or a square can be calculated using the same formula:

$$A = l\,h$$



$A = Area\ (m^2)$

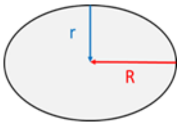
$l = length\ (m)$

$h = height\ (m)$

1.3 Area of an Oval

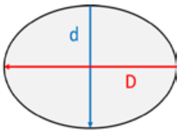
The area of an oval is calculated using the following formula:

$$A = \pi\,R\,r$$



Or

$$A = \frac{\pi\,D\,d}{4}$$



$A = Area\ (m^2)$

$R = major\ radius\ (m)$

$r = minor\ radius\ (m)$

$D = major\ diameter\ (m)$

$d = minor\ diameter\ (m)$

1.4 Questions and Solutions

Question (area of a circular hood or duct)

The radius of a circular duct is measured to be 0.2 metres. Calculate the cross-sectional area of the duct.

Solution

$$Area = \pi\,r^2$$

$$Area = \pi \times 0.2^2$$

$$Area = 0.12566\ m^2 \quad (to\ 5\ decimal\ places)$$

Note that the radius in this question was measured in SI units (metres). Therefore, no conversion was required.

Question (area of a rectangular hood)

The length and height of a rectangular hood were measured to be 0.3m and 200mm respectively. Calculate the area of the hood.

Solution

$$l = 0.3m$$

$$h\ (in\ metres) = 200mm\ \times 10^{-3}$$

$$A = l\ h$$

$$A = 0.3 \times 0.2$$

$$A = 0.06\ m^2$$

Note that the height of the hood was measured in millimetres (mm), which is not an SI unit. Therefore, we start by converting this value into a value in terms of metres.

Question (area of an oval hood)

The major radius and the minor radius of an oval hood were measured to be 0.15m and 0.1m respectively. Calculate the area of the hood.

Solution

$$A = \pi\ R\ r$$

$$A = \pi \times 0.15 \times 0.1$$

$$A = 0.0471\ m^2 \quad (to\ 4\ decimal\ places)$$

Advanced Question (used in LEV design calculations)

The area of a circular duct is $0.3\ m^2$. Determine the diameter (D) of the duct, giving your answer in millimetres.

Solution

$$A = \pi\ r^2$$

First, rearrange to make r the subject of the formula.

$$r^2 = \frac{A}{\pi} \quad (divide\ both\ sides\ of\ the\ equation\ by\ \pi)$$

$$r = \sqrt{\frac{A}{\pi}} \quad (square\ root\ both\ sides\ of\ the\ equation)$$

$$r = \sqrt{\frac{0.3}{\pi}}$$

$$r = 0.309\ m$$

Calculate the diameter by multiplying the radius by 2:

$$D = 2r$$

$$D = 2 \times 0.309$$

$$D = 0.618\, m$$

Convert the diameter from metres to millimetres:

$$D\ (in\ millimetres) = D\ (in\ meters) \times 10^3$$

$$D(mm) = 0.618 \times 10^3$$

$$D = 618\, mm$$

We could also use the following solution:

$$A = \frac{\pi D^2}{4}$$

Rearrange to make diameter (D) the subject of the equation:

$$4A = \pi D^2 \quad (multiply\ both\ sides\ by\ 4)$$

$$\frac{4A}{\pi} = D^2 \quad (divide\ both\ sides\ by\ \pi)$$

$$D = \sqrt{\frac{4A}{\pi}} \quad (square\ root\ both\ sides)$$

$$D = \sqrt{\frac{4 \times 0.3}{\pi}}$$

$$D = 0.618\, m$$

Convert the diameter (D) into millimetres:

$$D\ (in\ millimetres) = D\ (in\ metres) \times 10^3$$

$$D\ (mm) = 0.618 \times 10^3$$

$$D = 618\, mm$$

2. Velocity Measurements from Velocity Pressure

When velocity pressure readings are taken within an LEV system, there is a requirement to convert these pressures into velocities. Some measurement instruments may complete this conversion automatically. However, caution should be taken to understand the limitations of these instruments. Some instruments will take a measurement of air temperature at the instrument itself and therefore calculate velocities based upon the air density within the work room, rather than within the duct. Where duct/process air temperatures vary significantly from the work room air, significant errors can occur.

The formula to calculate the velocity from the velocity pressure is given as:

$$V = \sqrt{\frac{V_P}{0.5\rho}}$$

$V = Velocity\ (\frac{m}{s})$

$V_P = Velocity\ Pressure\ (Pa)$

$\rho = Air\ density\ (\frac{kg}{m^3})$

In some cases, it may be suitable to use the following simplified formula:

$$V = 1.29\sqrt{V_P}$$

Note: This simplified equation assumes an air density of $1.204\ kg/m^3$, which is the density of air at a temperature of $20^{\circ}C$ (room temperature) and pressure of 101.325 kPa (atmospheric pressure). If the temperature or pressure within a system differs from these values this simplified equation is not suitable and will produce incorrect results.

If the temperature and pressure are not 20^oC and 101.325 kPa, then the density (ρ) will need to be calculated using the ideal gas law below:

$$\rho = \frac{P}{R_{specific}\,T}$$

$$\rho = \frac{PM}{RT}$$

$$R_{specific} = \frac{R}{M}$$

$\rho = air\ density\ (\frac{kg}{m^3})$

$T = Absolute\ Temperature\ (K)$

$P = Absolute\ Pressure\ (Pa)$

$M = Molar\ mass\ \left(\frac{kg}{mol}\right) - dry\ air\ is\ approx.\ 0.02897\frac{kg}{mol}$

$R = Gas\ constant\ \left(\frac{J}{K \cdot mol}\right) - approx.\ 8.31446\frac{J}{K \cdot mol}$

$R_{specific} = Specific\ gas\ constant \left(\frac{J}{kg \cdot K}\right) - dry\ air\ is\ approx.\ 287\frac{j}{kg \cdot K}$

Note: The ideal gas law assumes that the gas behaves like an ideal gas. This law provides a good approximation for various gases under various conditions. In the case of LEV testing, we can usually make this assumption. However, when the gas cannot be assumed to be ideal, more advanced techniques would be required.

2.1. Questions and Solutions

Question

A pitot tube measurement records a velocity pressure of 144 Pa inside a duct. Calculate the velocity assuming room temperature and atmospheric pressure.

Solution

$$V = 1.29\sqrt{V_P}$$

$$V = 1.29 \times \sqrt{144}$$

$$V = 15.48\ m/s$$

Question

A manometer measurement records a velocity pressure of 151 Pa. Calculate the velocity where the density of air is 1.165 *kg/m*³ within the duct.

Solution

Since we are told that the density of air is $1.165\ kg/m^3$, we cannot use the simplified equation.

$$v = \sqrt{\frac{V_P}{0.5\rho}}$$

$$v = \sqrt{\frac{151}{0.5 \times 1.165}}$$

$$v = 16.1\ m/s$$

Advanced Question

A pitot tube measurement records a velocity pressure of 142 Pa. The absolute pressure is measured to be $101\ kPa$ and the absolute temperature is measured to be $306\ K$. The molar mass of the air is $0.02897\ kg/mol$. Calculate the velocity of the air inside the duct.

Solution

Since the absolute pressure is not at atmospheric pressure (101.325 kPa), we cannot use the simplified equation and the density of the air is unknown. Therefore, we must calculate the density.

$$\rho = \frac{PM}{RT}$$

$$\rho = \frac{101000 \times 0.02897}{8.31446 \times 306}$$

$$\rho \approx 1.15$$

$$v = \sqrt{\frac{V_P}{0.5\rho}}$$

$$v = \sqrt{\frac{142}{0.5 \times 1.15}}$$

$$v \approx 15.7\ m/s$$

3. Volumetric Flowrate

The volumetric flowrate (or volume flowrate) is the amount of fluid that flows through a specific cross-sectional area per unit time. The volumetric flow is calculated using the following formula:

$$Q = vA$$

$\mathrm{Q} \ = \ \text{volumetric flowrate} \ (m^3/s)$

$v = velocity \ (m/s)$

$A = cross \ sectional \ area \ (m^2)$

3.1 Questions and Solutions

Question

The velocity inside a 350mm diameter duct is measured to be 10 m/s. Calculate the flowrate.

Solution

Convert the diameter of the duct from millimetres to metres.

$$d(m) = d(mm) \times 10^{-3}$$

$$d(m) = 350 \times 10^{-3}$$

$$d(m) = 0.35 \ m$$

Calculate the cross-sectional area of the duct.

$$A = \frac{\pi D^2}{4}$$

$$A = \frac{\pi \times 0.35^2}{4}$$

$$A = 0.0962$$

Using the volumetric flowrate formula.

$$Q = vA$$

$$Q = 10 \times 0.0962$$

$$Q = 0.962 \ m^3/s$$

Advanced Question

The velocity pressure inside a 450mm diameter duct is measured to be 144 Pa. Calculate the flowrate assuming room temperature and atmospheric pressure.

Solution

We can calculate the velocity from the velocity pressure value given (as shown in section 1.2). Since we are assuming room temperature and atmospheric pressure, we can use the simplified equation.

$$v = 1.29\sqrt{V_p}$$

$$v = 1.29\sqrt{144}$$

$$v = 15.48\, m/s$$

Now convert the duct diameter into metres.

$$d(m) = 450 \times 10^{-3}$$

$$d(m) = 0.45\, m$$

Calculate the cross-sectional area.

$$A = \frac{\pi D^2}{4}$$

$$A = \frac{\pi \times 45}{4}$$

$$A = 0.159\, m^2$$

Inserting these solutions into the flowrate formula:

$$Q = vA$$

$$Q = 15.48 \times 0.159$$

$$Q = 2.46\, m^3/s$$

4. Checking Solutions

In many of the calculations completed above, a simple trick can be used to check that the calculation and the units are correct. For example, when calculating the volumetric flowrate we use the following equation:

$$Q = vA$$

If we forget the units for the volumetric flowrate, we can work this out by the units of the velocity and cross-sectional area. Since velocity is measured in m/s and area is measured in m^2, then:

$$\frac{m}{s}\,(v) \times m^2 (A) = \frac{m^3}{s} (Q)$$

Using this trick, we may also be able to identify if we have missed a step during the calculations. For example, if we measure the diameter (in metres) of a duct but we forget to calculate the cross-sectional area, then we can notice this error by the units. This will produce a result with the units m^2/s (as shown below), which is the incorrect units for volumetric flowrate and therefore an incorrect result.

$$\frac{m}{s} \times m = \frac{m^2}{s} \quad (incorrect\ flowrate\ calculation)$$

This simple trick can reduce the probability of calculating incorrect results and using the wrong units. It is advised that the units of each element within a formula are used within all the calculations to reduce the chances of errors.

Note: The international system of units (SI units) must be used for all calculations. If any terms within a formula have been measured using different units (for example, millimetres, Celsius), then these will need to be converted into SI units.

Base Quantity	Unit	Symbol
Length	Metres	m
Mass	Kilograms	Kg
Time	Seconds	s
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BOHS is a Chartered, science-based, charitable body that provides information, expertise and guidance in the recognition, evaluation, control and management of workplace health risks.

BOHS was founded in 1953: it is a learned society, publishing the world-renowned, scientific, peer-reviewed journal, Annals of Work Exposures and Health, and the only professional society representing qualified occupational hygienists in the UK. The Society supports, develops and connects its members with resources, guidance, events and training.

Its Faculty of Occupational Hygiene sets professional standards, promotes professional development and maintains the UK's only accredited Register of Occupational Hygiene Professionals.

BOHS is the only occupational hygiene organisation to be awarded a Royal Charter: this was granted in April 2013 in recognition of BOHS' unique and pre-eminent role as the leading authority in occupational disease prevention.

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