2014

The Institution of Fire Engineers

Prepared by Richard Fowler
MSc, BEng(Hons), CFIFireE

[FORMULA BOOKLET]

V1.4

This formula booklet has been prepared to assist students sitting Fire Engineering Science papers in the IFE examinations. It is intended to supplement other learning and draws together the main formula that students should understand and be comfortable using. Many other formulas can be derived from those given in this booklet.

The Institution of Fire Engineers, IFE House, 64-66 Cygnet Court, Timothy's Bridge Road, Stratford Upon Avon, Warwickshire, CV37 9NW Telephone: +44 (0)1789 261463 Fax +44 (0)1789 296426
E- mail: exams@ife.org.uk www.ife.org.uk

INDEX

L3 DIPLOMA – FIRE ENGINEERING SCIENCE

1. EQUATIONS OF LINEAR MOTION

Equation	Quantities				
	s	u	v	a	t
$v = u + at$		✓	✓	✓	✓
$s = \frac{(u+v)}{2}t$	✓	✓	✓		✓
$s = ut + \frac{1}{2}at^2$	✓	✓		✓	✓
$v^2 = u^2 + 2as$	✓	✓	✓	✓	

Where: v = Final velocity in metres per second (m/s)

u = Initial velocity in metres per second (m/s)

a = Acceleration in metres per second per second (m/s/s or m/s^2)

t = Time in seconds (s)

s = Distance travelled in metres (m)

2. NEWTON'S LAWS OF MOTION

1. An object continues in its state of rest or of uniform motion in a straight line unless acted upon by an external force.

2. A change in motion (acceleration) is proportional to the force acting and takes place in the direction of the straight line along which the force acts.

   Acting force = mass x acceleration caused

   or, $F = m \times a$

3. To every action there is an equal and opposite reaction (or, if object A exerts a force on object B, then object B exerts an equal, but oppositely-directed, force on A).

3. MASS, WEIGHT AND MOMENTUM

$$F = m \times a$$

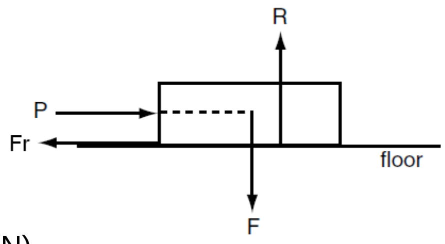
Where: F = Force in newtons (N)

m = Mass in kilogrammes (Kg)

a = Acceleration due to gravity (constant) in metres/second/second (m/s^2)

(use 9.81 m/s^2)

$$P = \mu R$$



Where: P = Pushing (or applied) force in newtons (N)

μ = Friction factor (normally between 0.2 and 1)

R = Reaction force exerted by the floor in newtons (N)

$$R - F = 0 \quad \text{and} \quad P - F_r = 0$$

Where: P = Pushing (or applied) force in newtons (N)

F_r = Reactive friction force opposing the pushing force in newtons (N)

Note: These formula apply when the object is at rest or moving at a constant velocity.

4. WORK, ENERGY AND POWER

$$P = \frac{F \times d}{s}$$

Where: P = Power in watts (W)

F = Force in newtons (N)

d = Distance in metres (m)

s = Time taken in seconds (s)

$$Efficiency = \frac{useful\ output\ energy}{input\ energy}$$

or

$$Efficiency = \frac{useful\ output\ power}{input\ power}$$

$$W = Pt$$

Where: W = Work done (J)

P = Power in watts (W)

t = Time taken (s)

$$W = Fd$$

Where: W = Work done (J)

F = Force (N)

d = Distance (m)

Energy

$$KE = \frac{1}{2}mv^2$$

Where: KE = Kinetic energy in Joules (J)

m = Mass in Kilogrammes (Kg)

v = Velocity in metres per second (m/s)

$$PE = mgH$$

Where: PE = Potential (gravitational) energy in Joules (J)

m = Mass in Kilogrammes (Kg)

g = Acceleration due to gravity (constant) in metres/second/second (m/s^2) (use 9.81 m/s^2)

H = Height of object above datum in metres (m)

Note: The potential energy calculated here is the energy of the object when held at height 'H' above the datum level.

$$v = \sqrt{2gH}$$

Where: v = Velocity in metres per second (m/s)

g = Acceleration due to gravity (constant) in metres/second/second (m/s^2) (use 9.81 m/s^2)

H = Height of object above datum in metres (m)

Note: The velocity calculated here is the velocity when the object reaches the datum level, when released from height 'H' above the datum level.

5. HYDRAULICS

$$P = \rho g H$$

Where: P = Pressure in pascal

ρ = Density of the fluid (normally 1000 kg/m^3 for fresh water)

H = Head (or depth) of fluid in metres

For fire ground use, this simplifies to:

$$P = \frac{H}{10} \quad \text{or} \quad H = 10P$$

Where: P = Pressure in bar

H = Head in metres

<u>Pressure loss due to Friction</u>

$$P_f = \frac{9000 f l L^2}{d^5}$$

Where: P_f = Pressure loss due to friction in bar

f = Friction factor for the hose (normally given in the question)

l = Length of the hose in metres

L = Flow rate in litres per minute

d = Diameter of the hose in millimetres

<u>Flow through a Nozzle</u>

$$L = \frac{2}{3} d^2 \sqrt{P}$$

Where: L = Flow rate in litres per minute

d = Diameter of the nozzle in millimetres

P = Pressure in bar

<u>Water power and Efficiency</u>

$$WP = \frac{100LP}{60}$$

Where: WP = Water Power in Watts

L = Flow rate in litres per minute

P = Pressure in bar

$$E = \frac{WP}{BP} \times 100$$

Where: E = Efficiency of a pump (%)

WP = Water Power in Watts

BP = Brake Power of engine in Watts

<u>Jet Reaction</u>

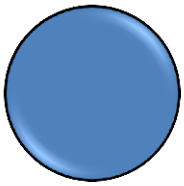
$$R = 0.157Pd^2$$

Where: R = Jet reaction in newtons

P = Pressure in bar

d = Diameter of the hose in millimetres

6. MATHEMATICS



Area of a Circle

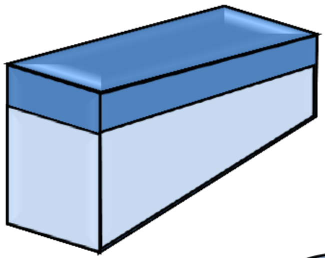
$$A = \pi r^2 \quad \text{or} \quad A = \frac{\pi d^2}{4}$$

Where: A = Area of circle in metres squared (m^2)

π = Pi (constant – use 3.1416)

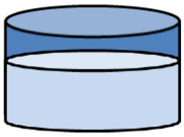
r = Radius of circle in metres

d = Diameter of circle in metres



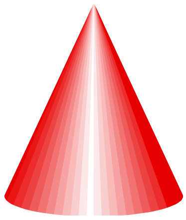
Volumes

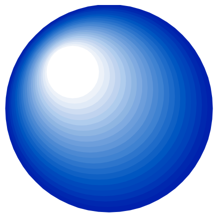
Sloping tank = length x breadth x average depth



Circular tank (cylinder) = $A = \pi r^2$ x depth or $A = \frac{\pi d^2}{4}$ x depth

Cone or pyramid = $\frac{area\ of\ base \times vertical\ height}{3}$





Sphere = $\frac{\pi d^3}{6}$ or $\frac{4\pi r^3}{3}$

Capacity of a pond = $\frac{2}{3} \times surface\ area \times average\ depth$

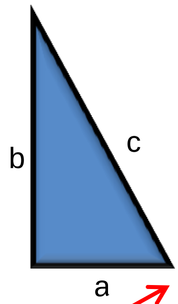
(this can be used as a rough approximation to find the amount of water in a pond)

Capacity of container (in litres) = volume (m^3) x 1000

Atmospheric pressure = 101,300 N/m^2 or 1.013 bar

Pythagoras

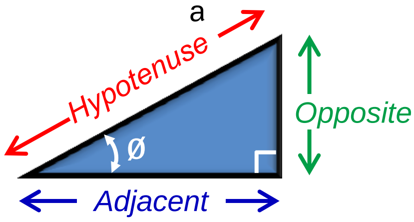
For finding sides of *right-angled* triangles.



$$a^2 + b^2 = c^2$$

$$c = \sqrt{a^2 + b^2} \qquad a = \sqrt{c^2 - b^2} \qquad b = \sqrt{c^2 + a^2}$$

SOHCAHTOA



SohCahToa is the easy way to remember how the Sine, Cosine and Tangent rules work.

soh… ***S**ine* = ***O**pposite* / ***H**ypotenuse*

*…**cah**…* ***C**osine* = ***A**djacent* / ***H**ypotenuse*

*…**toa**…* ***T**angent* = ***O**pposite* / ***A**djacent*

You can make-up any mnemonic that might help you remember theses, such as:

"**S**OME **O**FFICERS **H**AVE **C**URLY **A**UBURN **H**AIR **T**O **O**FFER **A**TTRACTION".

BODMAS

The acronym BODMAS defines the order of operations of mathematical functions. **"Operations"** mean things like add, subtract, multiply, divide, squaring, etc. If it isn't a number it is probably an operation.

The Correct order is:

- Brackets (parenthesis)
- Orders (powers and square roots)
- Division and multiplication
- Addition and subtraction

Sometimes called BIDMAS, where the 'I' stands for Indices (or powers).

Example

- **Do things in Brackets First.** Example:

✓ $6 \times (5 + 3) = 6 \times 8 = \mathbf{48}$

✗ $6 \times (5 + 3) = 30 + 3 = 33$ (wrong)

- **Exponents (Powers, Roots) before Multiply, Divide, Add or Subtract.** Example:

✓ $5 \times 2^2 = 5 \times 4 = \mathbf{20}$

✗ $5 \times 2^2 = 10^2 = 100$ (wrong)

- **Multiply or Divide before you Add or Subtract.** Example:

✓ $2 + 5 \times 3 = 2 + 15 = \mathbf{17}$

✗ $2 + 5 \times 3 = 7 \times 3 = 21$ (wrong)

- **Otherwise just go left to right.** Example:

✓ $30 \div 5 \times 3 = 6 \times 3 = \mathbf{18}$

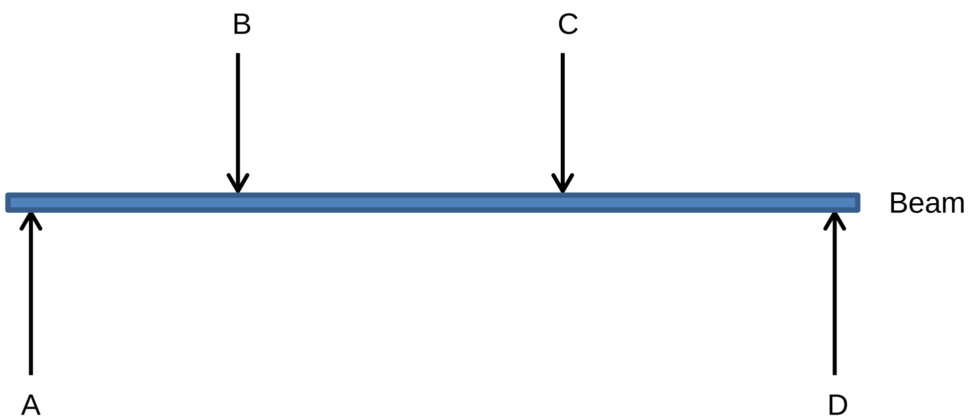
✗ $30 \div 5 \times 3 = 30 \div 15 = 2$ (wrong)

7.	EQUILIBRIUM IN MECHANICAL SYSTEMS

Conditions for Equilibrium

1. If an object is moving in a straight line, without accelerating or decelerating, the total (resultant or net) force acting on it must be zero.
2. If an object is not rotating, the total (resultant or net) moment (or turning force) acting on it must be zero.

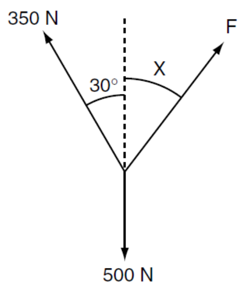
Condition 1: Parallel forces acting on a beam, supported at both ends

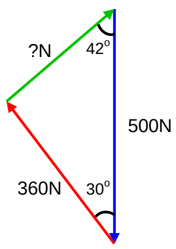


Total Upward Force = Total Downward Force

A + D = B + C

Condition 1: Non-Parallel Forces (vector forces)

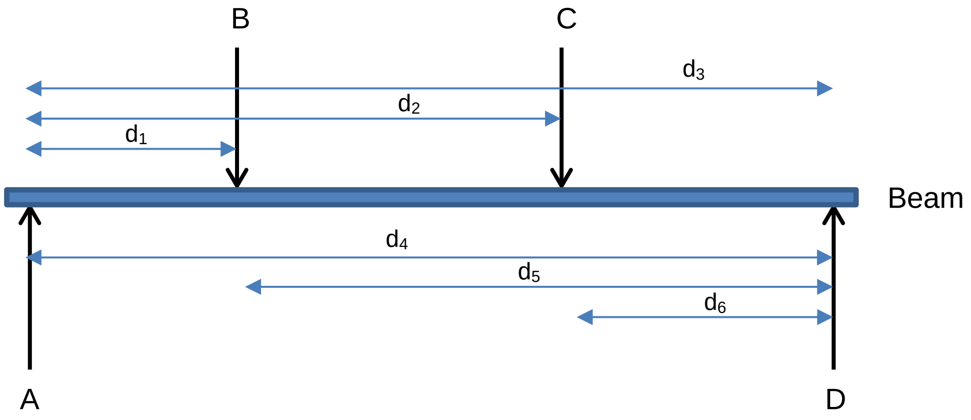




Solve by drawing a vector diagram to represent the forces. Represent the 500N vertical force with a 5cm vertical line. From the bottom of the line, add a 3.6cm line at 30°. Then join the two ends to form a triangle. The length and angle of the third line gives the third force (260N) and angle (42°).

Condition 2: Bending Moments (rotating)

Moment of a Force = Force x Distance



Take moments about a Point (i.e. for point A):

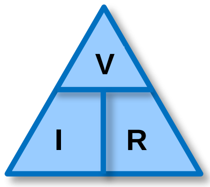
$0 = +(B \times d_1) + (C \times d_2) - (D \times d_3)$

…or about Point D:

$0 = +(A \times d_4) - (B \times d_5) - (C \times d_6)$

8. ELECTRICITY

$V = IR$

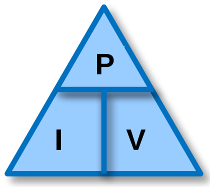


Where: V = Voltage in volts

I = Current in Amps

R = Resistance in ohms (Ω)

$P = IV$



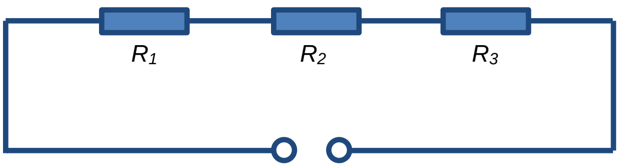
Where: P = Power in Watts

V = Voltage in volts

I = Current in Amps

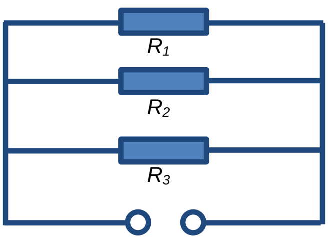
Resistors in series:

$$R_T = R_1 + R_2 + R_3$$



Resisters in Parallel:

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$



Resistivity:

$$R = \frac{\rho l}{a}$$

Where: R = Resistance in ohms (Ω)

ρ = Resistivity of conductor material in ohms per meter (Ω/m)

l = Length of cable in metres (m)

a = Cross sectional area in square metres (m^2)

$$R_t = R_0(1 + \alpha t)$$

Where: R_t = Final resistance of coil when heated to t°C in ohms (Ω)

R_0 = Resistance of coil at 0°C in ohms (Ω)

α = Temperature coefficient of resistance of a material in ohms (per/°C)

t = Final temperature in degrees centigrade (°C)

When two temperatures are given (i.e. when the starting temperature is not 0°C):

$$\frac{R_0}{R_t} = \frac{1 + \alpha_0 t_{ref}}{1 + \alpha_0 t_{final}}$$

Where: R_0 = Initial resistance of coil when heated to t_1°C in ohms (Ω)

R_t = Final resistance of coil when heated to t_2°C in ohms (Ω)

α_0 = Temperature coefficient of resistance of a material in (per/°C)

t_{ref} = Initial reference temperature in degrees centigrade (°C)

t_{final} = Final temperature in degrees centigrade (°C)

The "alpha" (α) constant is known as the *temperature coefficient of resistance*, and symbolizes the resistance change factor per degree of temperature change. Just as all materials have a certain specific resistance (at 20^{o}C – room temperature), they also *change* resistance according to temperature by certain amounts. For pure metals, this coefficient is a positive number, meaning that resistance *increases* with increasing temperature. For the elements carbon, silicon, and germanium, this coefficient is a negative number, meaning that resistance *decreases* with increasing temperature. For some metal alloys, the temperature coefficient of resistance is very close to zero, meaning that the resistance hardly changes at all with variations in temperature (a good property if you want to build a precision resistor out of metal wire!).

A more useful representation of this formula for finding R_t:

$$R_t = R_0\left[1 + \alpha\left(t_{final} - t_{ref}\right)\right]$$

Or, transposing to find t_{final}:

$$t_{final} = \left(\frac{\left(\frac{R_t}{R_0}\right) - 1}{\alpha}\right) + t_{ref}$$

9. HEAT

Heat is a form of energy and is measured in joules.

Absolute Zero = 0 K (Kelvin), or -273 °C

To convert: °C to K
K = °C + 273

To convert: K to °C
°C = K – 273

Thermal Capacity of a Body = Heat required to raise temperature of body (anything!) by 1 °C without changing its state.

Or, as a formula: $c = \frac{\Delta Q}{\Delta T}$

Where: c = Heat required (joules per degree centigrade J/^{o}C))
ΔQ = Heat transferred (joules J)
ΔT = Change in temperature (^{o}C)

Specific Heat Capacity (C) = Heat required to raise temperature of 1 gram of substance by 1 °C (or 1 K) without changing its state – in J/g/°C or J/Kg/K

$$c = \frac{\Delta Q}{m \times \Delta t}$$

Where: c = Specific Heat Capacity of substance (in J/Kg°C)
ΔQ = Heat lost/change (in joules)
m = Mass of substance (in Kg)
$\triangle$t = Change in temperature (in °C or K)

Latent Heat = Heat taken-in or given-out when a substance changes state
(e.g. from solid to liquid or liquid to gas)

Specific Latent Heat of Fusion = Amount of heat required to change 1 Kg of solid at its melting point to a liquid (with the temperature remaining constant). Opposite effect is Specific Latent Heat of Solidification.

Specific Latent Heat of Vaporisation = Amount of heat required to change 1 Kg of a liquid to a gas (the liquid being at its boiling point). Opposite effect is Specific Latent Heat of Condensation.

Enthalpy = measure of the total energy of a thermodynamic system.

Enthalpy: $\triangle H_{Fusion} = -\triangle H_{Solidification}$ $\triangle H_{Vaporisation} = -\triangle H_{Condensation}$

Endothermic (requires heat) Exothermic (releases heat)

Expansion

Co-efficient of Linear Expansion = Increase in unit length per degree rise in temperature

Linear expansion is two-dimensional expansion, e.g. the change in the length of a steel beam through heating (Note: The beam will expand in three dimensions but if we are only interested in the change in length, we will calculate the linear expansion the less significant expansion in the second and third dimensions).

$$L_{Exp} = l \times \propto \times \Delta T$$

Where: L_{Exp} = Expansion (in metres)

l = Length before heating (in metres)

$\propto$ = Coefficient of linear expansion

ΔT = Change in temperature (in °C or K)

Co-efficient of Superficial Expansion = Increase in unit area per degree rise in temperature

Superficial (or areal) expansion is a change in the area of the sides of a solid material through heating.

$$A_{Exp} = A \times 2 \propto \times \Delta T$$

Where: A_{Exp} = Increase in area (in square metres)

A = Area before heating (in square metres)

$\propto$ = Coefficient of linear expansion

ΔT = Change in temperature (in °C or K)

Co-efficient of Cubical Expansion = Increase in unit volume per degree rise in temperature

Cubical (or volumetric) expansion is three-dimensional expansion, e.g. the change in volume of a sphere through heating.

$$V_{Exp} = V \times 3 \propto \times \Delta T$$

Where: V_{Exp} = Expansion in volume (in cubic metres)

V = Volume of beam before heating (in cubic metres)

$\propto$ = Coefficient of linear expansion

ΔT = Change in temperature (in °C or K)

Coefficient of **superficial** expansion = 2 x Coefficient of **linear** expansion

Coefficient of **cubical** expansion = 3 x Coefficient of **linear** expansion

---

For a solid, the linear expansion is linked to the superficial expansion and the cubical expansion.

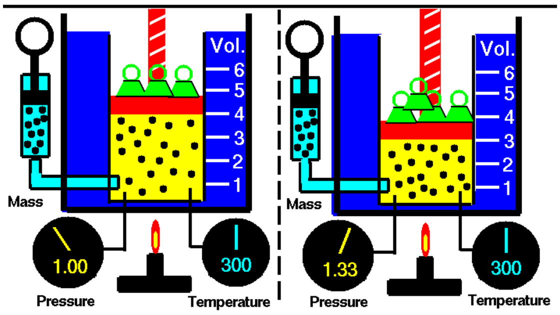
For liquids and gases there is just cubical expansion.

10. THE GAS LAWS

Boyle's Law

The volume of a given mass of gas is inversely proportional to the pressure upon it if the temperature remains constant.

$$P_1 \times V_1 = P_2 \times V_2$$

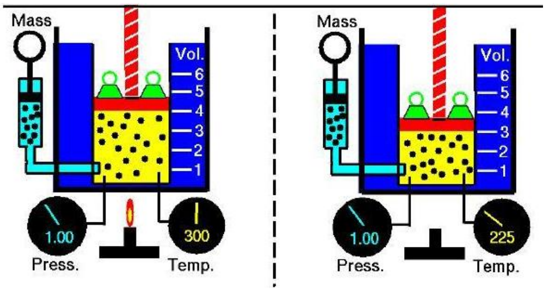


Where: P_1 = Initial pressure (in bar)
V_1 = Initial volume (in cubic metres)
P_2 = Final pressure (in bar)
V_2 = Final volume (in cubic metres)

Charles's Law (also known as the law of volumes)

The volume of a given mass of gas is directly proportional to the temperature of the gas in kelvin.

Gay-Lusacc's Law $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

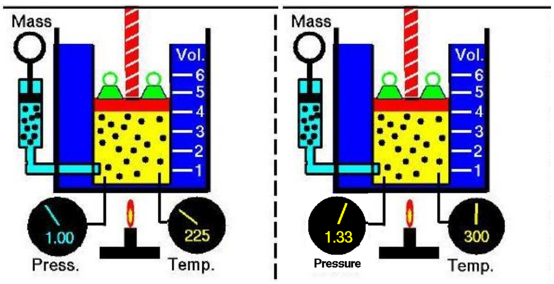


Where: V_1 = Initial volume (in cubic metres)
T_1 = Initial temperature (in Kelvin)
V_2 = Final volume (in cubic metres)
T_2 = Final temperature (in Kelvin)

The Law of Pressures (also known as the Gay-Lusacc's Law)

The pressure exerted on a container's sides by an ideal gas is proportional to its temperature.

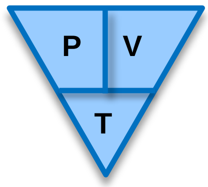
$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$



Where: P_1 = Initial pressure (in bar)
T_1 = Initial temperature (in Kelvin)
P_2 = Final pressure (in bar)
T_2 = Final temperature (in Kelvin)

The Combined Gas Law (or General Gas Equation)

Combination of previous laws:



$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

Where: P_1 = Initial pressure (in Bar)

V_1 = Initial volume (in cubic metres)

T_1 = Initial temperature (in Kelvin)

P_2 = Final pressure (in Bar)

V_2 = Final volume (in cubic metres)

T_2 = Final temperature (in Kelvin)

Note: When using the gas laws **all temperatures must be in Kelvin**.

L4 CERTIFICATE – FIRE ENGINEERING SCIENCE

For the Level 4 Certificate, students will need to be familiar with all of the formula shown above for Level 3 Diploma students, plus those shown below, which are specific to the Level 4 Certificate syllabus.

11. HYDRAULICS

Bernoulli's Equation

Bernoulli's equation describes the relationship between pressure energy, potential energy and kinetic energy in a system. These forms of energy can be interchanged but unless energy is added to, or taken out or a system, the total energy present remains constant at any point. When writing Bernoulli's equation, each term must stand alone as a true representation of the form of energy concerned.

$$P_1 + \rho g H_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g H_2 + \frac{1}{2}\rho v_2^2$$

Where: P = pressure in pascal

ρ = Density of the fluid (normally 1000 kg/m^3 for fresh water)

g = acceleration due to gravity (constant 9.81 m/s^2)

H = Height in metres

v = velocity of water in metres per second

Liquid Flow in pipes – Pressure loss due to friction

$$H_f = \frac{2flv^2}{Dg}$$

Where: H_f = pressure loss (Head) due to friction (in metres head)

f = friction factor due to roughness of the pipe (no units)

l = Length of hose (in metres)

v = velocity of water (in metres per second)

D = Diameter of hose (in metres)

g = acceleration due to gravity (constant 9.81 m/s^2)

By converting metres-head to bar and diameter of hose to millimetres, this may also be expressed as:

$$P_f = \frac{20flv^2}{d}$$

Where: P_f = pressure loss due to friction (in bar)

f = friction factor due to roughness of the pipe (no units)

l = Length of hose (in metres)

v = velocity of water (in metres per second)

d = Diameter of hose (in millimetres)

<u>Continuity Equation</u>

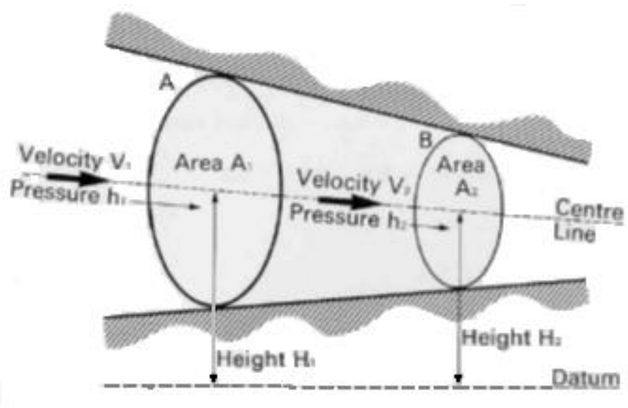
$Q_1 = Q_2$ and $A_1 V_1 = A_2 V_2$

So: $Q_1 = A_1 V_1$ and $Q_2 = A_2 V_2$ and $Q_1 = A_2 V_2$ and $Q_1 = A_2 V_2$

Where: Q = Rate of flow (cubic metres per second m^3/s)

A = Area (square metres m^2)

V = Velocity (metres per second m/s)

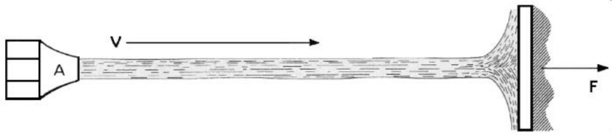


<u>Converting Pressures</u>

Pressures are often given in different units, and it may be necessary to convert from one value to another. The following table shows the conversions:

	Pascal	Bar	m/H	N/m²	psi
Pascal		÷ 100,000	÷ 10,000	x 1	÷ 6894
Bar	x 100,000		x 10	x 100,000	÷ 0.07
m/H	x 10,000	÷ 10		x 10,000	÷ 0.7
N/m²	x 1	÷ 100,000	÷ 10,000		÷ 6894
psi	x 6894	x 0.07	x 0.7	x 6894	

Force exerted by a jet on a flat surface



$$F = \rho v^2 A$$

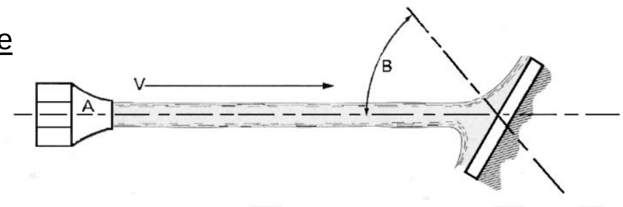
Where: F = Force on plate (in newtons N)

ρ = Density of fluid (normally 1000 kg/m^3 for fresh water)

v = velocity of water (in metres per second m/s)

A = Area of nozzle (in square metres m^2)

Force exerted by a jet on an *inclined* flat surface



$$F = \rho v^2 A \cos\theta$$

Where: F = Force on plate (in newtons N)

ρ = Density of fluid (normally 1000 kg/m^3 for fresh water)

v = velocity of water (in metres per second m/s)

A = Area of nozzle (in square metres m^2)

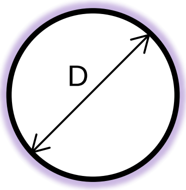
θ = Angle of inclination from the vertical (in degrees)

Hydraulic Mean Values

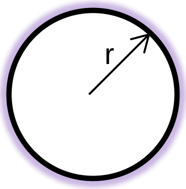
$$Hydraulic\ mean\ radius\ (or\ diameter) = \frac{cross\text{-}sectional\ area\ of\ flow}{wetted\ perimeter} \quad \text{or} \quad m = \frac{A}{P}$$

Where: m = Hydraulic mean diameter

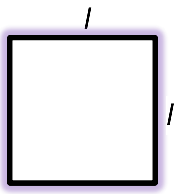
D = Diameter of pipe in metres



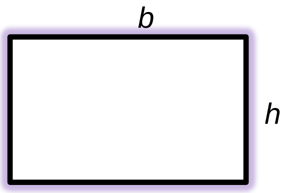
$$m = \frac{\frac{\pi D^2}{4}}{\pi D} = \frac{D}{4}$$



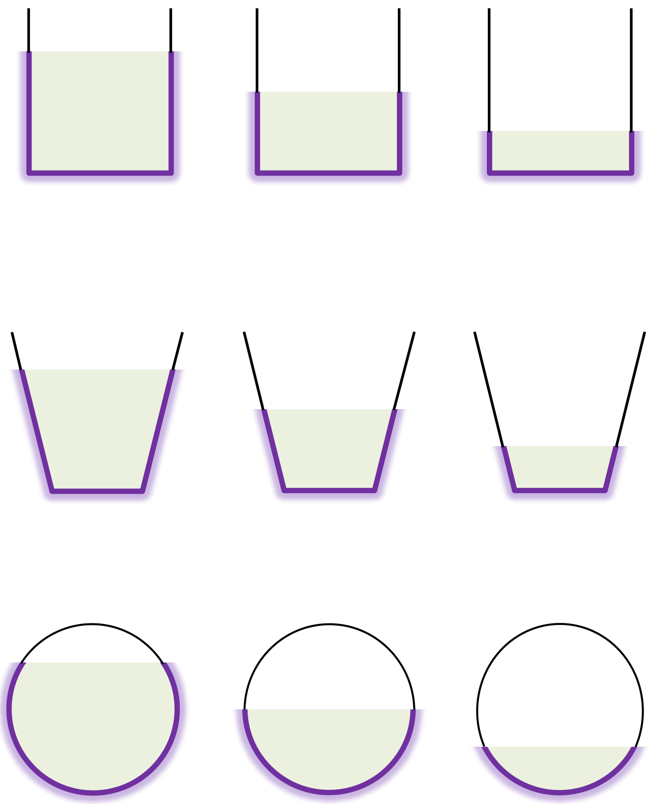
$$m = \frac{\pi r^2}{2\pi r} = \frac{r}{2}$$



$$m = \frac{l^2}{4l} = \frac{l}{4}$$



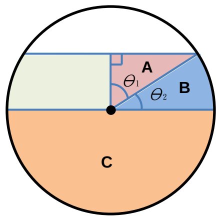
$$m = \frac{h \times b}{2(h+b)}$$



For the rectangular and trapezoid, the calculations are relatively straight forward, but for the circular channel, the calculations are more complex as they involve calculating the length of an arc of the circle (as the wetted perimeter) and the area of a section of the circle.

The length of an arc can be found from $= \theta \frac{\pi}{180} r$ degrees

The area of the section of pipe is more complex. The section must be broken into several sections and the area of each found:



Section A is a right-angled triangle.

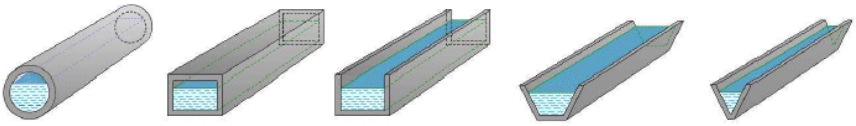
Section B is a segment of the circle: Area $= \frac{r^2}{2}\left(\frac{\pi}{180}\theta - sin\theta\right)$

Section C is half a circle: Area $= \frac{\pi r^2}{2}$

Area = (A x 2) + (B x 2) + C

Sufficient dimension would need to be provided for this calculation.

12. LIQUID FLOW IN OPEN CHANNELS



$$Q = vA$$

Where: Q = Flow (in m^3 per second)

v = velocity of water (in metres per second)

A = Area of cross section of water in open channel (in metres squared)

And 'v' can be found from the 'Chezy Formula':

$$v = C\sqrt{mi}$$

Where: v = velocity of water (in metres per second)

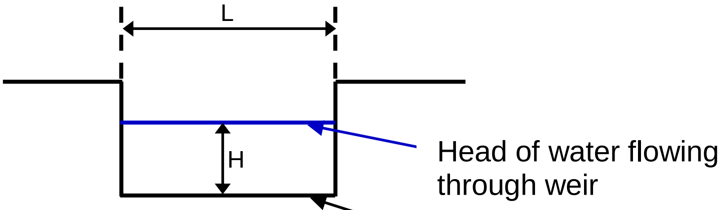
C = Chezy constant (in $m^{1/2}/s$)

m = Hydraulic mean depth of water (in metres)

i = Incline of the channel (expressed as a ratio)

13. MEASURING FLOW THROUGH AN OPEN CHANNEL

Rectangular Weir



$$Q = \frac{2}{3} C L \sqrt{2g}\, H^{1.5}$$

Where: Q = Flow of water through the weir (in cubic metres per second)

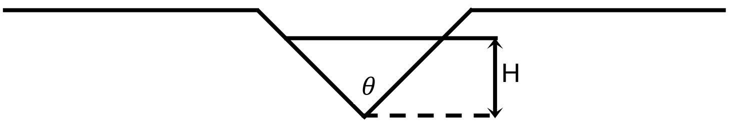
C = Weir Coefficient (Chezy constant) (in $m^{1/2}/s$)

L = Length (or width) of weir (in metres)

g = acceleration due to gravity (constant 9.81 m/s^2)

H = Head on the weir, measured above the crest (in metres)

Vee-notch Weir



$$Q = \frac{8}{15} C \tan\frac{\theta}{2} \sqrt{2g} H^{2.5}$$

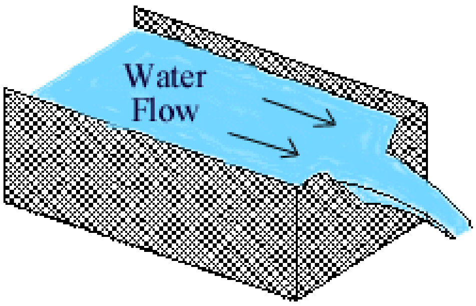
Where: Q = Flow of water through the vee-notch (in cubic metres per second)

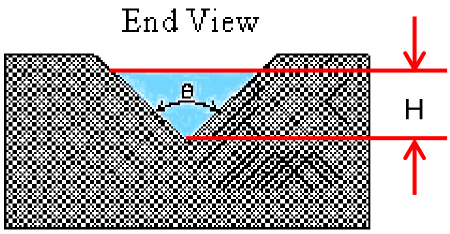
C = Weir Coefficient (Chezy constant) (in $m^{1/2}/s$)

θ = Angle of vee-notch (in degrees)

g = acceleration due to gravity (constant 9.81 m/s^2)

H = Depth of water in the vee-notch (in metres)





14. TRANSFORMER RATIO

$$\frac{V_P}{V_S} = \frac{N_P}{N_S} = \frac{I_S}{I_P}$$

Where: V_P = Primary voltage in volts (V)

V_S = Secondary voltage in volts (V)

N_P = Primary turns (count)

N_S = Secondary turns (count)

I_P = Primary current in amps (A)

I_S = Secondary current in amps (A)

15.	FIRE DYNAMICS

Law's Law

When a fire is burning steadily and the composition of the burning material is known, it is possible to calculate the length of time that the fire will burn. The time that the fire will burn (fire resistance) is related to the surface area of the walls and ceilings (excluding the ventilation openings).

Law's correlation between fire resistance requirement (t_f) and $L/(A_w A_t)^{1/2}$

$$t_f = \frac{k \times L}{\sqrt{(A_W \times A_t)}} \text{ (kg/m}^2\text{)}$$

Where: t_f = Time that fire lasts (fire resistance) (min)
L = Fire load (Kg)
A_w = Area of ventilation (m^2)
A_t = Internal surface area of compartment (m^2)
k = Constant (near unity, and normally therefore ignored)

By use of this formula, it is possible to calculate the resistance (in minutes) that a door must have to allow for the safe exit of people from a building.