MATHS REVISION For P601/P602

OK – so it may have been a while since you did this at school?

If you are happy with the following equations then you need read no further than this front page!

Typical Equations Used in P601/P602

Area of a circle	=	$\pi D^2/4$	Where $\pi = 3.142$ D = dia (m)
Or	=	πr^2	Where r = radius in metres(!)
Velocity (V)	=	$1.29\sqrt{VP}$	Where VP = Velocity Press (Pa)
Velocity Pressure	=	$(V/1.29)^2$	V = Velocity in m/s
Flowrate, Q	=	**V x A**	Where V = velocity in m/s A = area in m Q = m^3/s

If the above seems like a foreign language then enlist the help of someone in the family doing this at school and/or try to follow the arguments in the following pages.

If they seem a bit complicated – **YOU MUST** try to get someone to work through the maths with you before the course.

We do go through the maths in the class – but if these maths ideas are truly new to you then you will struggle if you have not had a 'go' at reading these notes!

The morning Open-Book exam paper uses the above maths—hence it is so important that you come to the course able to follow these concepts

First—DONT PANIC!! Some of this might look daunting at first sight—but get a coffee and sit down and work through the text below.

Lets try …… Areas of a Circle!

You can use either of the two equations on the previous page but I prefer **$\pi D^2/4$** because you will normally measure your duct as a "*Diameter*" and not as a Radius.

That simply means you take **π** and multiply it by **D** and again by **D** and then divide the answer by **4**

π is always **3.142** (don't know why – it just is ….. always!)

Just a word on the **units** we use.

Usually we measure duct diameters in **mm** but we display areas in **m^2.**

So when we use the equations (either one on previous page) for calculating areas – the first thing we have to do is convert the diameter in **mm** into a diameter in **metres**.

You do this by dividing the diameter in **mm** by 1000 (as there are 1000mm in 1m). So a 200mm duct is 0.2m diameter and a 450mm duct is 0.45m in diameter and so on.

Let's try some Duct Area calculation examples:-

Say you have a duct diameter measured at 200mm – what is the duct area?

First
convert the diameter in mm to a diameter in metres. So 200mm becomes 200/1000 which is 0.2m. **So …. D = 0.2m**

Second
Using the equation **Area = $\pi D^2/4$** and putting in the values for **π** and **D** we get the following:-

$$A = \frac{3.142 \times 0.2 \times 0.2}{4} = 0.0314m^2$$

Exercise 1: Now try some on your own:-

What would be the area of the following ducts (go to 4 numbers after the decimal point as we did in the example above):-

100mm
150mm
250mm
300mm
500mm

Note: Round your answers to the 4 decimal point, ie 0.0196375 becomes 0.01963

(Answers if you want to check are on the back of the last page)

How to get VELOCITY from a VELOCITY PRESSURE?

The Pitot Tube connected to a manometer takes duct velocity readings but in reality it takes **Velocity Pressure** readings and in the exam you need to be able to convert those to **Velocities (in m/s).**

Yes—I know your machine does the conversion automatically but the Examiners are sadists and you will need to do the calcs!!

The equation we use for this is:-

Velocity **=** $1.29\sqrt{V_P}$ Where V_P = Velocity Press (measured in Pascals)

To work it out ……. Simply put the velocity pressure into your calculator screen—press the square root key (**the one which looks like** √) and multiply the answer you get by 1.29

Lets look at an example:-

Pitot Tube and manometer records an average Velocity Pressure of **148Pa**.

What would the velocity be at that point?

Using the above equation – the first thing to do is put the **148Pa** into your calculator and then hit the "√" button.

That should give you the answer **12.17**.
(actually 12.16552 but we round it up to 2 decimal places)

Then
Multiply this by **1.29** (from the equation above) to get the final answer of **15.69m/s** (metres/second), ie 12.17 x 1.29 = 15.699 m/s

I guess if we round this up correctly we get the answer 15.70 m/s —but we are not going to fall out over that miniscule difference!

Exercise 2 – Some you can try **(answers on back page)**

What would be the velocity (in m/s) where the following velocity pressures were measured in the ducts?

116Pa
180Pa
224Pa
475Pa

How to get a VELOCITY PRESSURE from VELOCITY?

Just occasionally we need to do this velocity/velocity pressure calculation the other way round. This is particularly needed when doing LEV design.

So if we re-arrange the previous equation:-

Velocity = $1.29\sqrt{V_P}$

Scramble it a bout a bit (maths teachers love doing this :-) —we can get the following equation (trust me it is correct—and your old maths teacher would agree with me!)

Velocity Pressure = $(V/1.29)^2$

The two 'blue' equations above are actually mathematically identical!! Strange …. but true!

So if the exam question asks for the **Velocity Pressure** and it gives you the **Velocity** (eg a velocity of 15m/s) you could work out what the **velocity pressure** would have been.

Example

Lets use this figure (ie 15m/s) in the above equation.

Velocity Pressure, $V_P = (V/1.29)^2$ which = $(15/1.29)^2$

And $(15/1.29)^2 = (11.63)^2$

To square a number you simply multiply it by itself. So:-

$(11.63)^2$ is the same as 11.63 x 11.63 which = **Velocity Pressure** of **135.3Pa!**

Exercise 3 – Some you can try **(answers on back page)**

What would be the velocity pressure, **Vp** (in Pa) for the following velocities?

10m/s
16m/s
20m/s
25m/s
32m/s

How to Calculate FLOWRATE, "Q"?

We now know how to calculate **Areas** and **Velocities**.
Now we need to look at **Flowrate** which is obtained from the following equation:-

Flowrate, Q = V x A

In this case Flowrate, "Q" can either be in **m^3/s** or **m^3/hr**

Velocity will always be in **m/s**
Area will always be in **m^2**

So if you do nothing else the answer for Flowrate "Q" from the above equation will give the result in m^3/s

Example:-

Velocity = 15m/s
Area of Duct = $0.0707m^2$ (a 300mm diameter duct)

Q = V x A

So - **Q = 15 x 0.0707 which = 1.0605 m^3/s**

What if we wanted this in m^3/hr instead of m^3/s?

There are 60 minutes in an hour and 60 seconds in a minute therefore there are 3600 seconds in an hour!

**** To get m^3/s into m^3/hr – simply multiply the m^3/s answer by 3600 ***.

In the above example **Q = 1.0605m^3/s** which is 1.0605 x 3600 = **3818m^3/hr**

Exercise 4 – Some you can try **(answers on back page)**

What would be the flowrates in BOTH m^3/s and m^3/hr for the following velocities and areas?

A = $0.196m^2$, Velocity = 24m/s
A = $0.0176m^2$, Velocity = 12m/s
A = $0.0707m^2$, Velocity = 16.8m/s
A = $0.0314m^2$, Velocity = 9.6m/s

How to Calculate Pressures?

We have one final equation and it relates to what we get from the Pitot Tube/ Manometer. Depending on how we connect the tubes to the Pitot Tube we can record the following in a ducting:-

Total Pressure (Tp) sometimes written **Pt**
Static Pressure (Sp) sometimes written **Ps**
Velocity Pressure (Vp) sometimes written **Pv**

They are all bound and related by the following simple equation:-

Tp = Sp + Vp

Vp is ….. **ALWAYS ……** a **positive** number for example; +240 or +365

Sp however is ……. **negative before the fan** (suction) and ……. **positive after the fan** (most of our readings are before the fan so a negative number is the more common)

Suppose for example you are working in the duct **before** the fan and the readings you get are **Vp = 350Pa** and **Sp = -800Pa** (note the minus sign!)

Using the equation:- **Tp = Sp + Vp**

This would mean that **Tp** = -800 +350 which = **-450** (note the minus sign again!)

It is not so easy if they give you Tp and (say) Sp and ask you to work out Vp.

First we need to remind ourselves of a maths rule we learned at school (but maybe have forgotten??). Don't ask ***why*** it works – it just does!!

See that equals sign? "=" in any equation? ……. Well think of it as a river and if you take something across from one side to the other it changes (mathematical) sign; eg a plus number becomes a negative number and vice versa. Let's look at an example:

Tp = -600Pa
Sp = -900Pa What would be the Vp??

OK so the equation we use is:-

Tp = Sp + Vp

Putting the figures in the example into the equation we get:-

-600 = -900 + Vp

Hmm! But what we want is VP on its own.

So we take Sp across the river ie across to the other side of the "=" sign ,...... but if we do that a "-" would become a "+". So -900Pa static pressure would become +900Pa. See below:-

-600 + 900 = Vp

In other words **Vp would = +300Pa**

Exercise 5 – Some you can try **(answers on next page)**

What would be the answer in the following examples:-

Tp = -240,	Sp = -760	What would Vp be?
Tp = +100,	Sp = -200	What would Vp be?
Vp = 350,	Tp = -400	What would Sp be?
Vp = 240,	Sp = -960	What would Tp be?
Tp = -60,	Sp = -300	What would Vp be?

Maths is not so Bad?

Answers:

Exercise 1

100mm	=	$0.0079m^2$
150mm	=	$0.0177m^2$
250mm	=	$0.0491m^2$
300mm	=	$0.0707m^2$
500mm	=	$0.1964m^2$

Exercise 2

116Pa	13.89m/s
180Pa	17.31m/s
224Pa	19.31m/s
475Pa	28.11m/s
624Pa	32.22m/s

Exercise 3

10m/s	60Pa
16m/s	153.8Pa
20m/s	240.4Pa
25m/s	375.6Pa
32m/s	615.3Pa

Exercise 4

A = $0.196m^2$,	Velocity = 24m/s	Q = $4.704m^3/s$ or $16,934m^3/hr$
A = $0.0176m^2$,	Velocity = 12m/s	Q = $0.211\ m^3/s$ or $760m^3/hr$
A = $0.0707m^2$,	Velocity = 16.8m/s	Q = $1.188\ m^3/s$ or $4,276m^3/hr$
A = $0.0314m^2$,	Velocity = 9.6m/s	Q = $0.301\ m^3/s$ or $1,085m^3/hr$

Exercise 5

Tp = -240,	Sp = -760	Vp = 520Pa
Tp = +100,	Sp = -200	Vp = 300Pa
Vp = 350,	Tp = -400	Sp = -750Pa
Vp = 240,	Sp = -960	Tp = -720Pa
Tp = -60,	Sp = -300	Vp = 240Pa