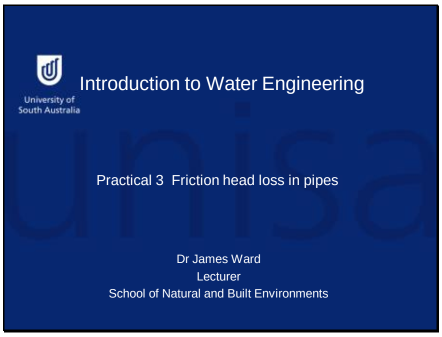
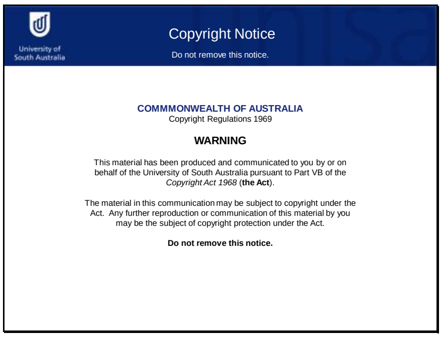
Slide 1



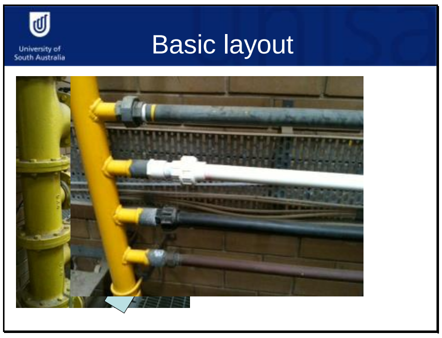
This is a walkthrough of the prac on pipe friction head losses

Slide 2



Please note

Slide 3



At UniSA we're lucky to have one of the largest pipe friction loss rigs in the country. The basic layout of our rig's like this.

The main manifold delivers water to any one of these 25 millimetre pipes

Or the bigger 100 millimetre pipes.

Here's a closeup of the 25 millimetre pipes – the top one's galvanised steel, the white one below it's PVC plastic, then black poly pipe and the bottom one's copper. We'll just be using the top 3 pipes in the prac today.

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Here's the view from the other end of the rig. We use valves at this end of the rig to direct flow through whichever pipe we want to measure.

So that could be one of the 25 millimetre ones up here

Or one of the 100 millimetre ones. The total length of these pipes is about 27 metres, and coupled with a pump that's capable of delivering 100 metres of head and up to 500 litres a second of flow, we've got a good opportunity to see some significant velocities and resultant pressure losses in these pipes due to friction.

Like in the flow measurement prac, we want to be able to measure pressure at any one of a number of different places on the rig,

so we use tapping points like this

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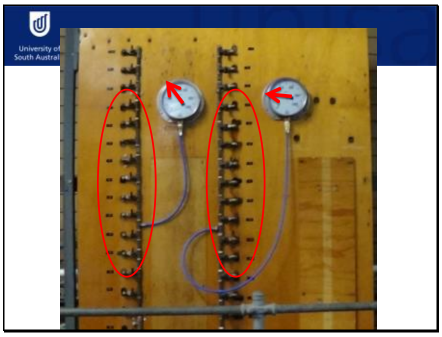
The tapping points are connected to a series of long, small tubes which all converge at a central manifold, again like the flow measurement rig we used last time.

Slide 6



And this is the front of the manifold.

We use a set of valves to select which upstream tapping point we want to connect to the upstream gauge

And likewise, which downstream one we want to use.

The pressure gauges each give a reading in kilopascals, and since the pipes are all of uniform cross-section and laid horizontally, the difference between the upstream and downstream pressure gives us the energy head loss.

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As well as the various pipes, we can measure the energy head loss across a number of different devices like this gate valve.

You can see the upstream and downstream tapping points here, which connect to the manifold we just looked at.

Of course, the pressure difference we measure here isn't just due to the minor loss of the device. Because the tapping points are a reasonable distance apart – like about half a metre or so – there's a small amount of energy lost due to pipe friction in that section. You'll be using the pressure head loss data to work out the minor loss coefficient of these devices, so it's important to correct the observed pressure head loss to account for the part that's not actually due to minor losses.

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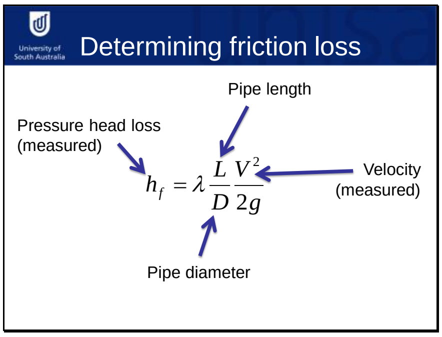

Okay, so by now you should be familiar with the Darcy equation for friction head loss.

In this case the head loss is actually the thing we're measuring – we're measuring it in kilopascals so you'll have to convert it into metres of water.

The pipe length's been given

and so's the diameter of each pipe. So the remaining items here are lambda, the friction factor, and the velocity.

We're going to measure velocity in this case, and rearrange the equation to calculate lambda.

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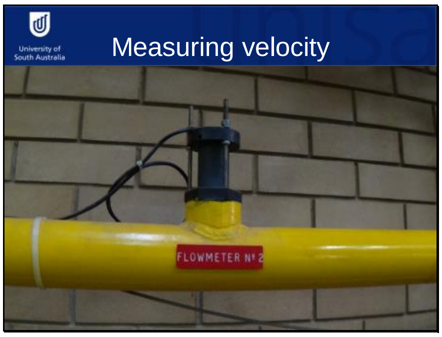

We measure volumetric flow rate using a flow meter, and you'll have to convert this to a velocity based on the cross-sectional area of each pipe.

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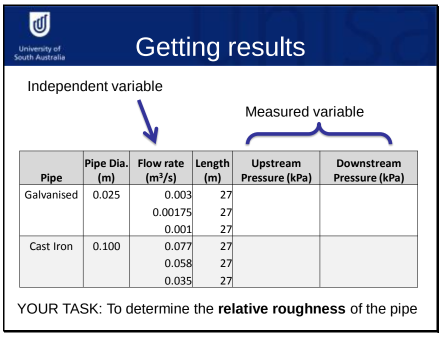

Pipe	Pipe Dia. (m)	Flow rate (m^3/s)	Length (m)	Upstream Pressure (kPa)	Downstream Pressure (kPa)
Galvanised	0.025	0.003	27		
		0.00175	27		
		0.001	27		
Cast Iron	0.100	0.077	27		
		0.058	27		
		0.035	27		

YOUR TASK: To determine the **relative roughness** of the pipe

So you'll be given some data like this, except for a few more pipes and the minor loss devices too.

In each case there's the independent variable, which is the flow rate here – we run three different flows through each pipe to get some different values of head loss. Notice the difference in flow rate between the 25 and 100 millimetre pipes; the bigger pipe can handle much larger flows.

The measured variables are the upstream and downstream pressures. The upstream minus the downstream gives the overall pressure head loss, which you'll use in solving the Darcy equation. The best thing to do is set up your calculations in a spreadsheet, and once you've done it for one value on one row, you can copy the formula down and it'll update the calculations for all of your other ones.

Now your task in all this is to use the observed data to calculate the relative roughness of each pipe. Let's see how you might go about doing that.

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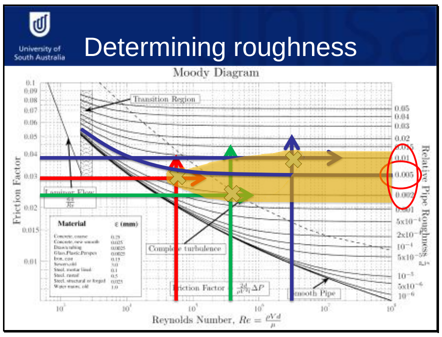


So hopefully you can calculate lambda easily enough by rearranging the Darcy equation. You also need to calculate the Reynolds number, which is simple since you know all the parameters.

For each pipe, running the different velocities gives different Reynolds numbers

and you should have a different value of lambda for each one, too – they might not be all that different, it depends where they are on the overall curve.

So let's say for a particular pipe you've come up with these combinations of Reynolds number and lambda, which plot up on the Moody diagram like this.

Now what you'd really like to see is your three points all lining up on a curve,

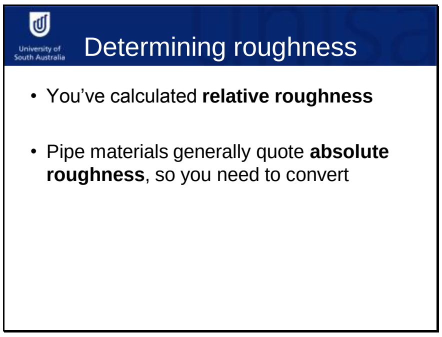
because that'd give you a definitive value of the relative roughness for your pipe.

But realistically, there's a lot more uncertainty in this type of prac and it's more likely your results are going to plot up like this. Actually you'll be lucky if they're even as close as this. Sometimes they plot up and they're off the curves altogether!

So in this case what you've got is a small sample, giving a range of values. Here you can't really mount a substantial argument as to roughness being closer to the 0.01 end or the 0.002 end, because of limited data. The most you can do with this is really quote the range. Obviously if you need to, you can interpolate and quote values of relative roughness that are in between the values on the right-hand side here. Remember that in prac reports, a lot of your discussion should be commenting on sources of error and uncertainty in your results. So you should pay close attention to this – if you're lucky enough to find that in a few cases the points actually line up along one of the curves, then maybe that means you can have a bit more confidence in those ones than in the ones where the points are all over the place.

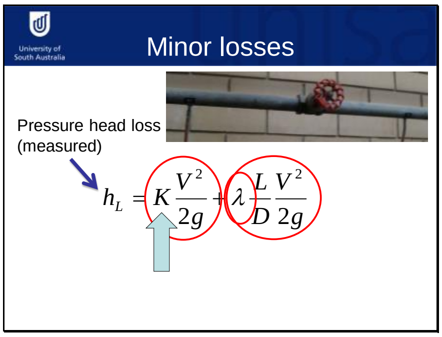
Image source - http://upload.wikimedia.org/wikipedia/commons/8/80/Moody_diagram.jpg

Slide 12



So now what you should have is a value of relative roughness, which is the ratio of the average bump size on the pipe surface to the diameter of the pipe. In order to compare against other values, like values in your textbook or maybe values you get from searching the internet, you need to convert these relative roughness values into absolute roughness, in other words just expressing the average bump size. This is a property of the material, so smooth materials like PVC are expected to have small bumps and rougher materials have larger bumps.

Slide 13



In the case of the minor loss devices,

the measured pressure head loss

is actually the sum of the minor losses

and the friction head loss over the short section of pipe. The friction head loss shouldn't be too much, given it's only a short distance between the two tapping points, but it's big enough to need us to include it in the calculation.

In this case what we want is to calculate the minor loss coefficient of each device and compare it with published values for similar devices. You can rearrange the equation easily to give K in terms of all the other parameters,

but to solve for K you're going to need a value for lambda. You've got all the other parameters from the experiment. Luckily, if you do the major loss calculations first, you'll actually have an idea of the relative roughness for a 25 millimetre galvanised steel pipe. Once you've got that, you can use the Moody diagram or the Moody equation to work out lambda and substitute it into this equation. That brings us to the end of the walkthrough for this prac. All the best with it!