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# A heavy topic

In a previous issue we looked at the ramifications for picture framers, of Pythagoras' squaring of the triangle. A natural extension of this discovery in mathematics is the later development of the field of trigonometry ~ Remember Sin, Cos & Tan?

Well their fundamental properties are arrived at through the use of a triangle within a circle. And trigonometry is, before anything else, a useful tool for examining triangles. Given one side length and one corner angle, Sin, Cos and Tan enable us to calculate the other side lengths and all angles of a triangle.

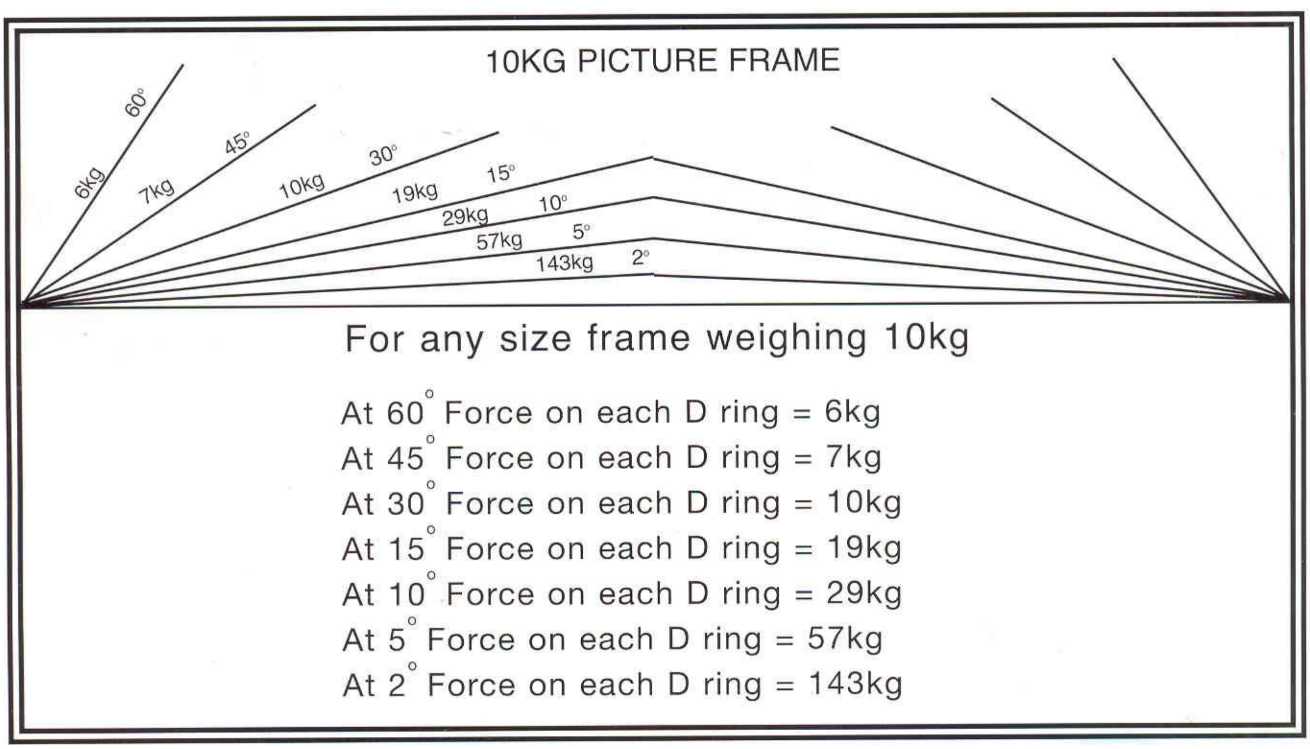
In an early issue of Profile we looked at the forces which act on the hangers on a frame. This article proved to be one of the most popular we have ever published. Many framers still use it to demonstrate to their customers the need to use two wall hooks when hanging heavy frames. We are often asked to update the article so here we present it again with a deeper explanation of the maths involved.

Trigonometry can be applied to the directional forces acting on a humble D-ring on the back of a frame, to work out the optimum stringing arrangement. Usually we use two D-rings on the frame and a wire forming a triangle onto a single mounting point on the wall. A bit of maths can show that this is far from the optimal approach.

If one wall hook is used to hang a frame, the downward force on the hook is simply the weight of the frame. If two wall hooks are used the force on each of those wall hooks is half the weight of the frame. This is perfectly obvious. What is less obvious is how the forces acting on the actual D rings change radically according to how we arrange the hooks on the wall. Or more accurately the forces on the D rings change radically according to the angle of the hanging wire.

A fundamental formula tells us that the sine of an angle equals the length of the side opposite the angle, divided by the length of the hypotenuse. So we have a formula....Sin(a) = W/F. W is the weight and F represents the force while (a) is the angle. The weight (W) is exactly half the weight of the frame (the other half is taken by the other D-ring). The force along the direction of the string (F) can then be derived from our formula. After a little algebraic manipulation we get: F = W/2 sin(a)

And what does all this mean for the average framer? Basically, the looser the string, the larger the angle and consequently the less the force acting on the D-rings. The chart below shows the relevant forces acting on D-rings with the string at different angles.



The chart shows that if the wire is stretched taut (2 degrees) across the back of the frame, the force through the wire on each D-ring is over fourteen times the weight of the picture. Conversely, if the wire is fixed somewhat slack (say 30 degrees) across the back of the frame, the force on each D-ring is only equal to the weight of the picture. As the angle of wire becomes greater than 30 degrees the reduction of forces on the D rings is not particularly great. You will notice from the chart that as the angle becomes smaller than 30 degrees the story is very different. Now the forces become exponentially greater on our D rings. It is therefore important to keep our hanging wire at 30 degrees or more.

Now it doesn’t take Einstein to see that there is a limit to how steep the angle can be made before the nail in the wall is visible above the frame. Placing the D rings high up on the frame enables the frame to sit flush on the wall. At the same time this has the effect of reducing the angle of the wire. Placing the D rings lower helps with our angle but tends to cause the frame to lean forward on the wall.

The obvious remedy is to place 2 hooks in the wall. Therefore, as well as providing extra security for the actual wall fastening, placing 2 hooks in the wall increases the angle of the hanging wire. This in turn causes a huge reduction in the forces acting on the D rings of our frames. So having two hooks on the wall halves the load on each of the hooks so we have a safer situation. This is especially important for heavy frames. Two hooks also make the picture more stable. That is, once you have got the frame level on the wall it tends to stay that way. And it increases the angle of the hanging wire reducing forces on our D rings. So all this trigonometry, all the engineering and the mathematical calculations, leads us to conclude that two wall hooks are better than one.