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HS616: Literate Calculation

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Cake recipes can often times be elaborate, and require lots of ingredients and baking tools. Many of us have been in a situation where we return from the grocery store only to find that we are missing still missing something that is listed in the recipes, and are forced to make substitutions. Since baking is all about exact measurements, temperature, and time, it is vital that we make smart decisions about any substitutions to the recipe.

Let's take the following scenario: I have a cake recipe that requires me to use a 6" circle cake pan (that is 2" in depth), but I only have square cake pans (that are 2" in depth). What is the correct size square pan to use instead of a 6" circle cake pan?

In this case, we must find a square pan that fits the same volume of cake batter as a 6" round pan. The equation for calculation the volume of a round and square cake pan, respectively, are:

$$\text{Volume of a round cake pan} = (\pi) * r^2 * d$$

Where 'r' is the radius of the round pan and 'd' is the depth of the pan.

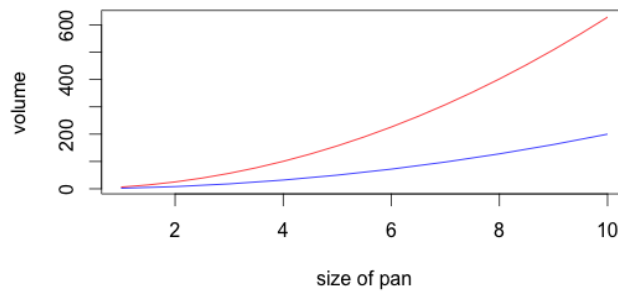
Note: radius= diameter/2 ; $(\pi) * r^2 * d = (\pi) * (\text{diameter}/2)^2 * d$

$$\text{Volume of square cake pan} = l^2 * d$$

Where 'l' is the length of one side of the square pan and 'd' is the depth of the pan.

For the scenario given above, $r=3$ (diameter=6) and $d= 2$. Given this value of r and d , we must calculate the appropriate l and d to determine the size of the appropriate square pan to use. Graphically, we can represent the total volume of the circle and square pans as follows:

```
>> v_circle <- function(diameter,d) pi * (diameter/2)^ 2* d
>> v_square <- function(l,d) l^2* d
>> vol<- function(r,d) sqrt((pi * r^2)/d)
>> plot((dia/2), v_circle(dia,d), type ='l', col="red", xlab="size of pan",
      ylab="volume")
>> lines(l, v_square(l,d), col="blue")
```



The graph above shows that the relative volumes for 1”- 10” circle pans (red) and square pans (blue) are not equal. Applying the to our scenario, we can see now that it does not make sense to substitute a 6” square pan for a 6” circle pan (as the recipe call for). So, let’s calculate the size of square pan that should be used to substitute for a 6” circle.

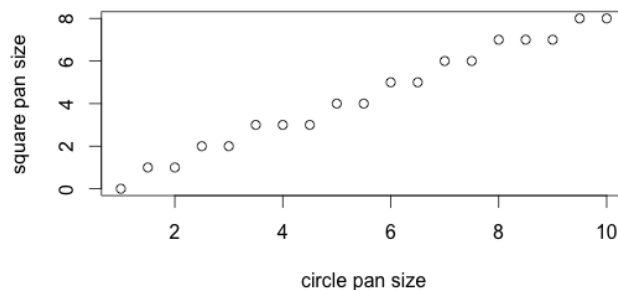
$$\text{Volume of a round cake pan} = \text{Volume of square cake pan}$$

$$(pi)*r^2*d = l^2*d$$

$$l = \sqrt{((pi)*r^2*d)/d}$$

We can plot all plot value for l for 1” to 10” circle pans. This will allow us to estimate the equivalent square cake pan and circle cake pan sizes without having to the math.

```
>> plot((dia/2), vol((dia/2),d), col="blue", xlab="circle pan size", ylab="square pan size")
```



For the scenario given, we can use the graph above to estimate that an a 5” square cake pan is the appropriate pan to use instead of a 6” circle pan.